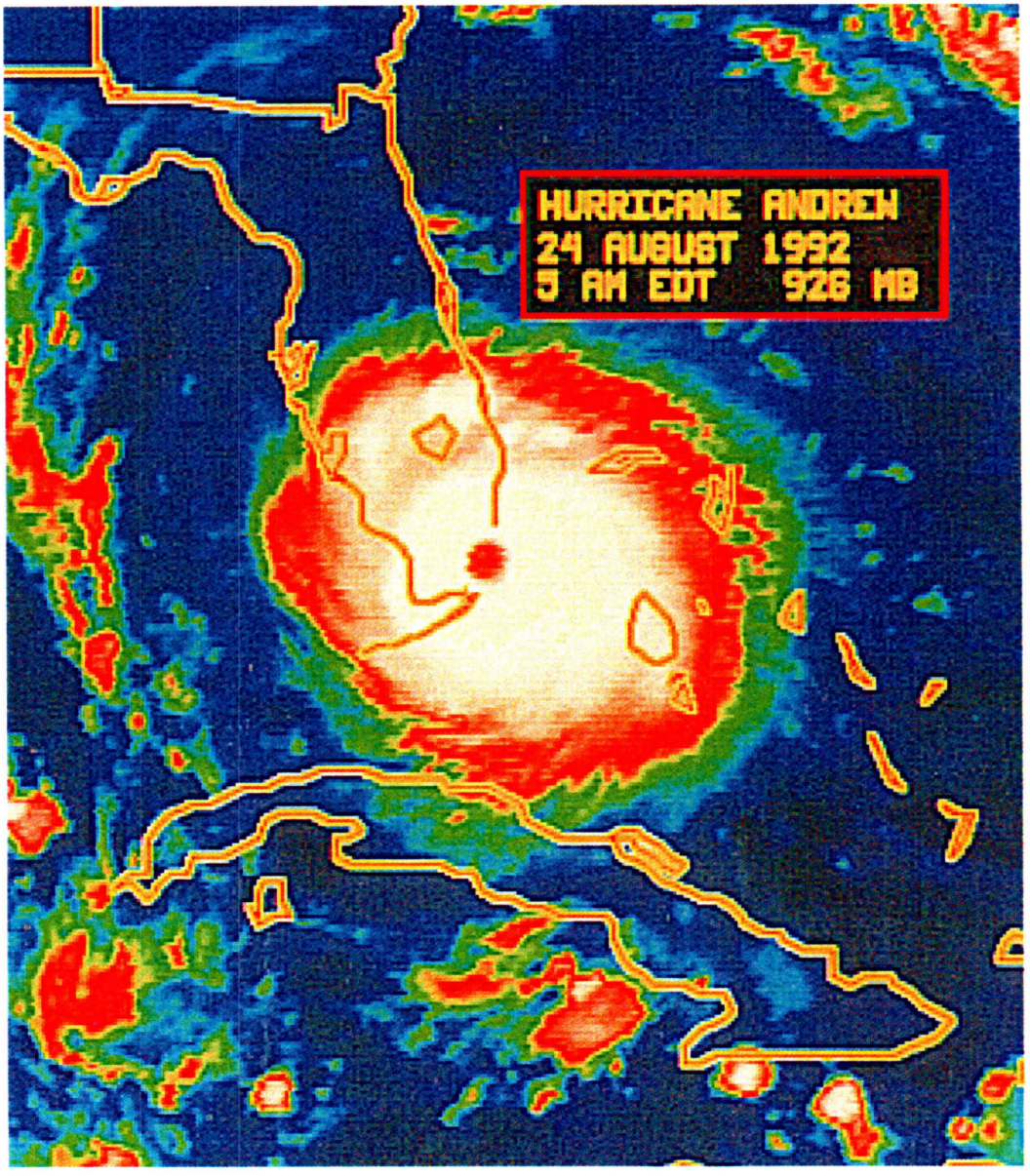
January 1993
Florida Version

US Army Corps
of Engineers

HURRICANE ANDREW ASSESSMENT

Review of Hurricane Evacuation Studies Utilization and Information Dissemination



HURRICANE ANDREW ASSESSMENT - FLORIDA
Review of Hurricane Evacuation Studies Utilization and Information Dissemination

Prepared for

U.S. Army Corps of Engineers
South Atlantic Division
and
Federal Emergency Management Agency
Region IV

Prepared by

Post, Buckley, Schuh & Jernigan, Inc.
134 South Bronough Street
Tallahassee, Florida 32301

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Introduction

On Monday morning, August 24, 1992, Hurricane Andrew tore through the southern peninsula of Florida. Andrew, the costliest and one of the strongest hurricanes of the century, left behind these mind-numbing statistics for South Florida (as reported by the Miami Herald):

- 20 billion dollars in total property damage
- 160,000 people left homeless
- 86,000 businesses destroyed or damaged
- 28,000 homes destroyed

A small but ferocious Cape Verde hurricane, Andrew wrought a path of destruction through the northwestern Bahamas, the southern tip of the Florida peninsula, and south central Louisiana. An estimated three-quarter of a million people evacuated dwelling units in South Florida alone. In Dade County, which took the brunt of the storm, 14 deaths were directly caused by Andrew. Of these, very few were from drowning - a testament to successful evacuations carried out by local emergency management officials throughout the threatened areas.

Prior to Hurricane Andrew, comprehensive hurricane evacuation studies had been completed for the lower southeast Florida coast (Monroe, Dade, Broward and Palm Beach counties). These studies and their associated work products were jointly funded by the Federal Emergency Management Agency (FEMA), the U.S. Army Corps of Engineers, the State of Florida Department of Community Affairs, and the National Weather Service. The Jacksonville District of the Corps of Engineers served as project manager for both the 1983 base study and the 1991 study update for lower southeast Florida.

With these studies in hand and a severe storm making landfall, a perfect opportunity was available to answer several key questions regarding these major FEMA/Corps planning efforts:

> Did local and state officials use the products produced in these major studies?
>
> Were study data regarding storm hazards, behavioral characteristics of the threatened population, shelter information, evacuation times, and decision-making accurate and reliable?
>
> Which study products were most useful and which least useful - what improvements could be made to current methodologies and products?

To answer these questions a study team comprised of William G. Massey representing FEMA; Royce Tipton, Joe Gavin and Allan McDuffie representing the Corps of Engineers; and Mike McDonald of the Florida Department of Community Affairs visited with local and state officials throughout the directly impacted areas of south Florida. Donald C. Lewis of Post, Buckley, Schuh & Jernigan, Inc. was retained to accompany the study team and document all relevant findings. Many local and state officials provided their observations. Local emergency management directors, law enforcement officers, and Red Cross personnel were primarily involved in meetings held in each area that responded to Hurricane Andrew. A separate meeting was held in Miami to discuss study product usage with local media representatives. Evacuation data were also obtained from several Southwest Florida and Treasure Coast regional counties to aid future FEMA/Corps of Engineers regional study efforts. Appendix A lists those individuals who either attended meetings or provided input through telephone conversations.

Discussion with local emergency management officials focused on study products and their use relative to the evacuation decision process, evacuation/traffic control and clearance, sheltering, and public information. Discussions with state officials centered on

the role the state played in the evacuation process, including the use (or non-use) of study products in communicating with local officials. Media representatives in Miami were asked to focus on study related materials that they possessed and that were broadcast to the general public. They also addressed the types of materials and public information they could have used that had not been developed or delivered to them to date.

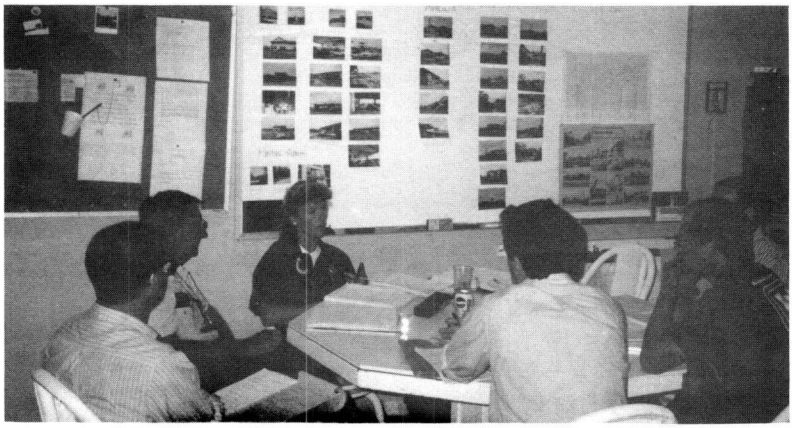
In addition to the meetings held with state and local officials, Hazards Management Group conducted and analyzed a residential behavioral sample survey for selected communities in the directly affected south Florida areas. Telephone interviews were conducted to compare actual evacuation response in Andrew to predicted evacuation response developed in the original comprehensive hurricane evacuation study. The behavioral analysis focused on the actual percent of the affected population that evacuated during Andrew, when the evacuees left their residence, what sort of refuge evacuees used, where the refuge was located, and the number of vehicles used by evacuating households.

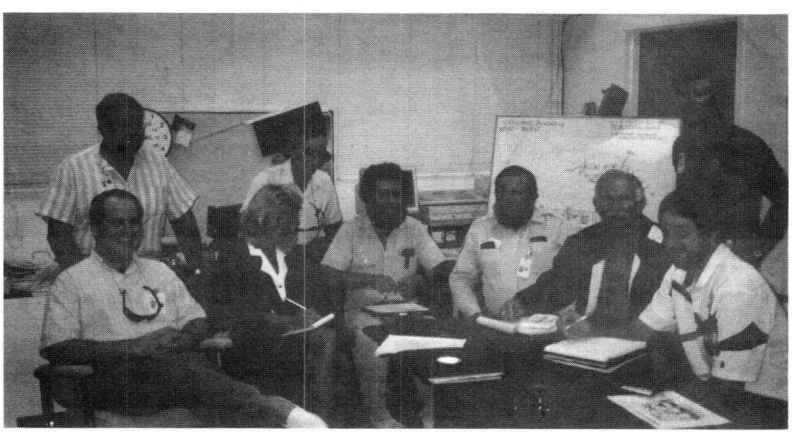
This report documents the findings of the study team and is organized by general category of hurricane evacuation study product. Those general categories that are addressed include:

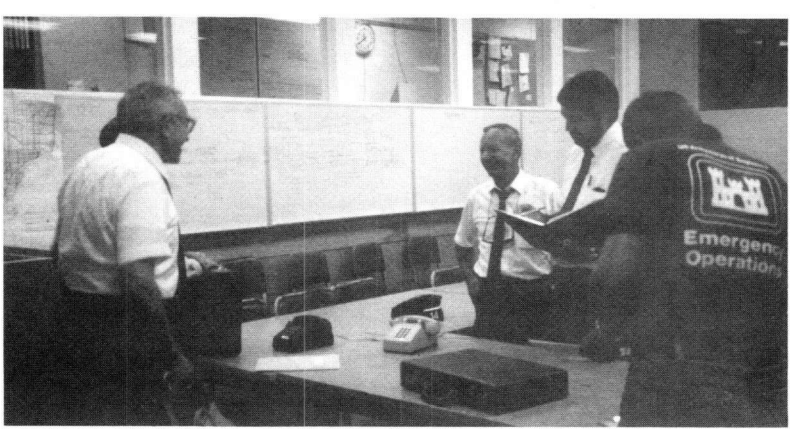
Hazards/Vulnerability Data
Behavioral Characteristics of Evacuees
Shelter Issues
Transportation/Clearance Time Data
Evacuation Decision-Making
Public Information

Each chapter describes typical study components and products produced in comprehensive hurricane evacuation studies. The chapter then summarizes actual data related to Andrew and compares it with study produced data for a relevant storm scenario. Recommendations are then given for future study efforts relative to that study topic.

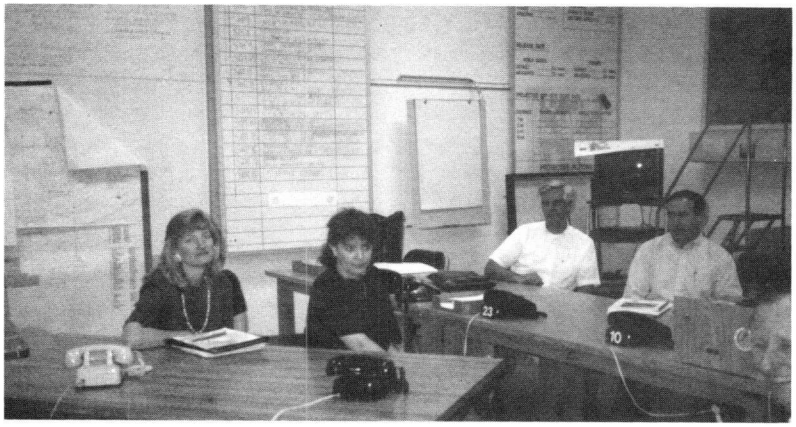
Representative Scenes at Local Coordination Meetings

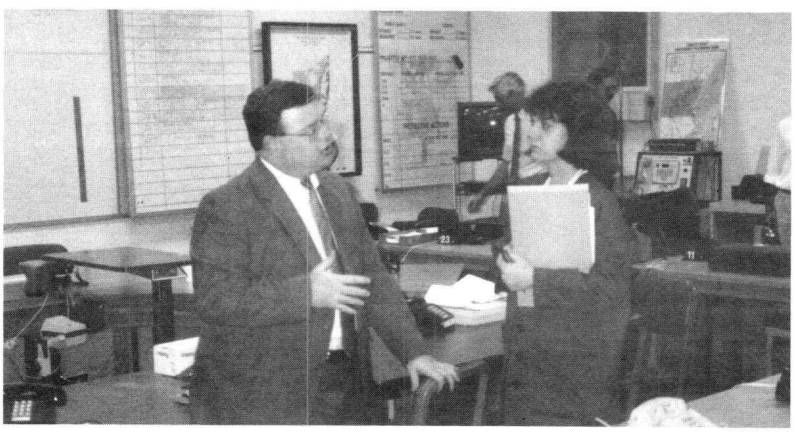






Representative Scenes at Local Coordination Meetings





Representative Scenes at Local Coordination Meetings

Chapter 2
Hazards/Vulnerability Data

In FEMA/Corps comprehensive hurricane evacuation studies, the primary objective of the hazards analysis is to determine the probable worst-case effects for the various intensities of hurricanes that could strike an area. Specifically, a hazards analysis quantifies the expected hurricane-caused inundation that would require emergency evacuation of the population. Historically, the hazards analysis also has assumed that mobile homes outside the surge inundation area must be evacuated due to their vulnerablity to winds. The National Weather Services' SLOSH (Sea, Lake, and Overland Surge from Hurricanes) numerical storm surge prediction model was used as the basis of the hazards analysis for studies completed in lower southeast Florida.

The vulnerability analysis uses the hazards analysis to identify the population potentially at risk to coastal flooding caused by the hurricane storm surge. Storm tide atlases are produced showing the inland extent of surge inundation for various hurricane intensities.

Hazards and vulnerability issues related to Andrew that were discussed with local and state officials included the following:

What technical data/mapping was used to choose the areas to evacuate?
Did the technical data provide a good depiction of the hazard area?

Inundation maps and evacuation zone maps developed from the SLOSH model output were heavily utilized study products during Andrew. Specifically, local emergency management directors decided whom to evacuate primarily on evacuation zone maps that were developed from the inundation mapping. In Dade County, each successive level of evacuation was clearly depicted on color coded public information handouts. Zip codes were shown on the map to facilitate understanding by the general public. Broward County, which had recently made major changes to its assumed Saffir-Simpson Category 4-5

4-5 evacuation zones (based on the latest SLOSH mapping), used a similar public information brochure.

Local emergency management directors had great confidence in the SLOSH model and took its data very seriously. As it did in Bulls Bay S.C. for Hurricane Hugo, the SLOSH model did an excellent job of predicting and then replicating the maximum surge height that occurred in Dade County where Andrew made landfall. Figure 1 graphically portrays a favorable comparison of profiles of observed high water marks versus SLOSH calculated storm tide heights along the western shore of Biscayne Bay.

While the SLOSH model did well in regards to surge height, the actual extent of flooding was less than expected and shown in the surge atlases. Figure 2 is a graphic that the Miami Herald developed (based on FEMA surveys) that shows the extent of surge flooding. Ironically, the areas that were evacuated in Dade County for expected category 4 flooding, were devastated by the winds of Andrew - if the evacuation had not been carried out in those areas, the loss of life would have been much greater.

Andrew was an unusually small and fast moving hurricane compared to worst case SLOSH modeled storms upon which the surge atlases were developed. Atlases show a composite of a number of tracks and foward speeds - Andrew was a single track with its own forward speed component. While the atlases assumed a Saffir-Simpson category 4 hurricane would drive water up from the south and around Cutler Ridge, Andrew had a very small eye and had its radius of maximum winds driving water up against Cutler Ridge. Through the Andrew experience, the National Hurricane Center learned that in south Dade County the SLOSH model needs a variable to account for wall fences like the one around the Deering Estate - apparently such walls and the debris that piles against them slows the advance of the storm surge.

From a meteorological standpoint, Hurricane Andrew was somewhat unusual - its rapid intensification and increase in forward speed created some interesting challenges for

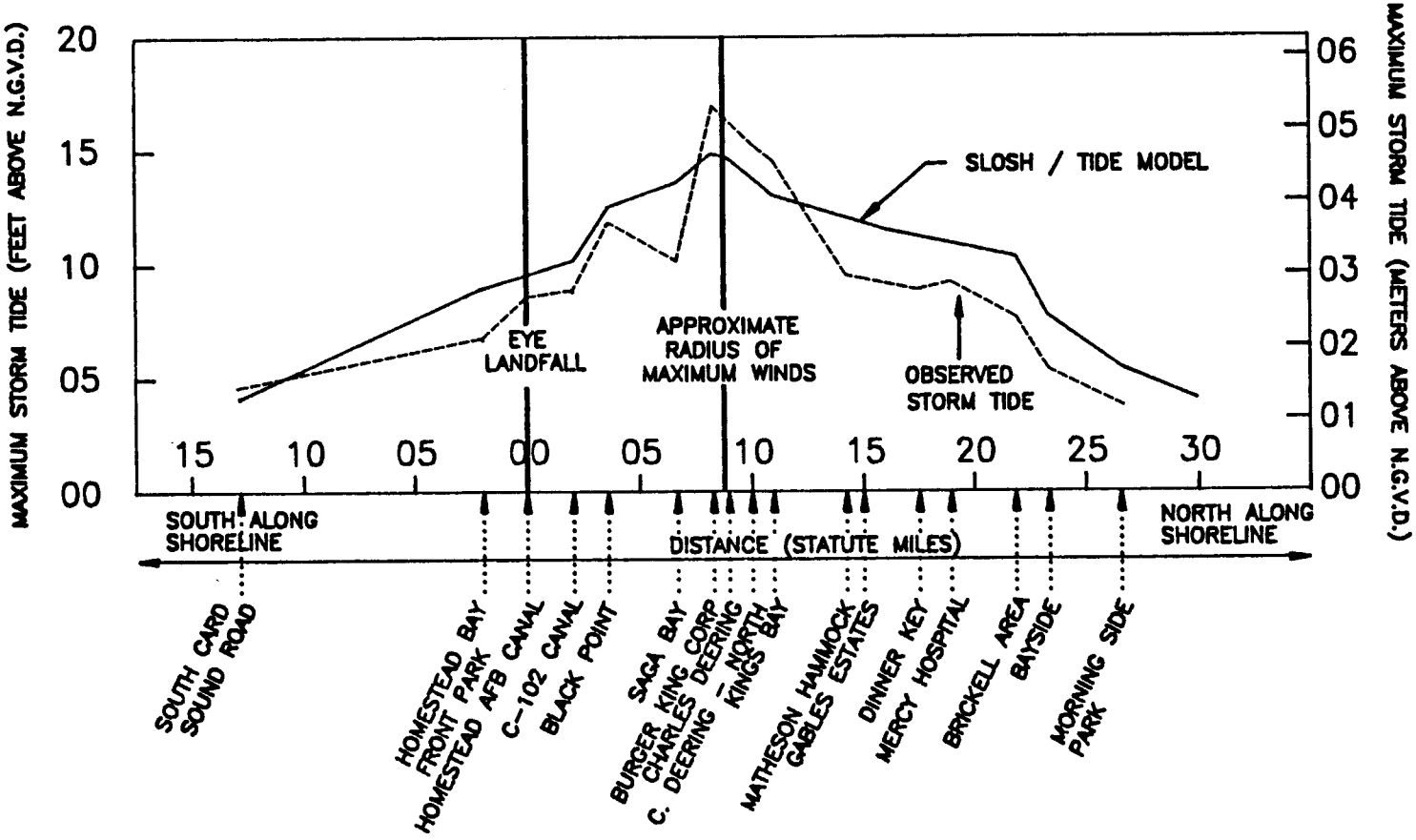


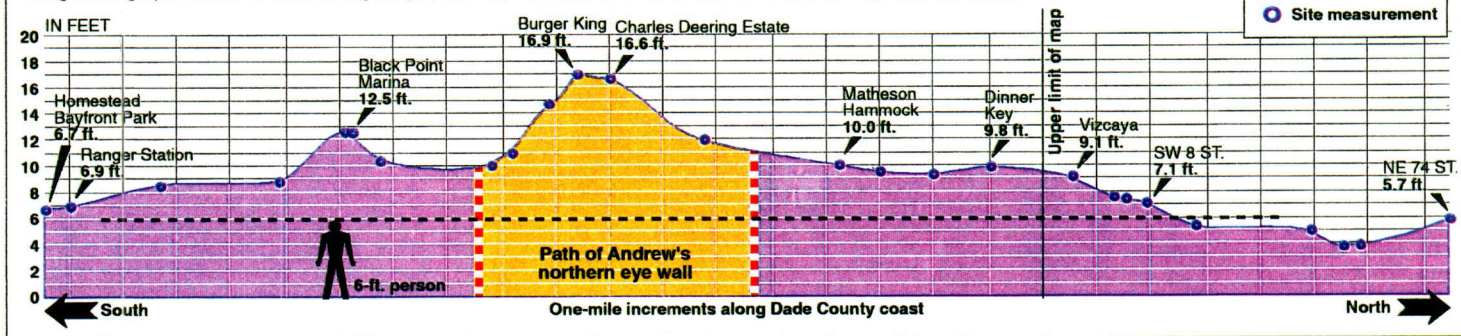
Figure 1

COMPARISON OF PROFILES OF OBSERVED VERSUS SLOSH/NOS MODEL CALCULATED STORM TIDE HEIGHTS ALONG WESTERN SHORE OF BISCAYNE BAY FOR HURRICANE ANDREW AUGUST 24, 1992. HEIGHTS IN FEET ABOVE NGVD- NATIONAL GEODETIC VERTICAL DATUM - ZERO ELEVATION - i.e. MEAN SEA LEVEL OF 1929).

(NHC-preliminary)

ANDREW'S STORM SURGE LEVEL

There are 4,300 flood claims as a result of hurricane Andrew's storm tide surge, which is a combination of tide waters and hurricane surge. The graph shows the coastal surge depth; the map the maximum inland extent of the surge, regardless of elevation.



The ocean's fury

by By STEPHEN K. DOIG
Herald Staff Writer

Hurricane Andrew's storm surge pushed seawater as much as three miles inland in places along the South Dade coastline, according to a recently-completed survey of flooding done for the Federal Emergency Management Agency.

The maximum depth of the storm tide, almost 17 feet above normal sea level, was found near the devastated corporate headquarters of Burger King, east of Old Cutler Road around Southwest 177th Street.

That peak was directly in the path of Andrew's north eyewall, the most intense part of the storm. The flooding along there reached almost to South Dixie Highway.

Elsewhere, the surge mostly stayed to the east side of Old Cutler Road. But tales abound of evacuees returning to their demolished homes to find crabs and fish among the debris in their swimming pools.

After the storm, Brian Jarvinen, the National Hurricane Center's expert on storm flooding, knew where they'd find the maximum storm surge: due east of his own house in Perrine.

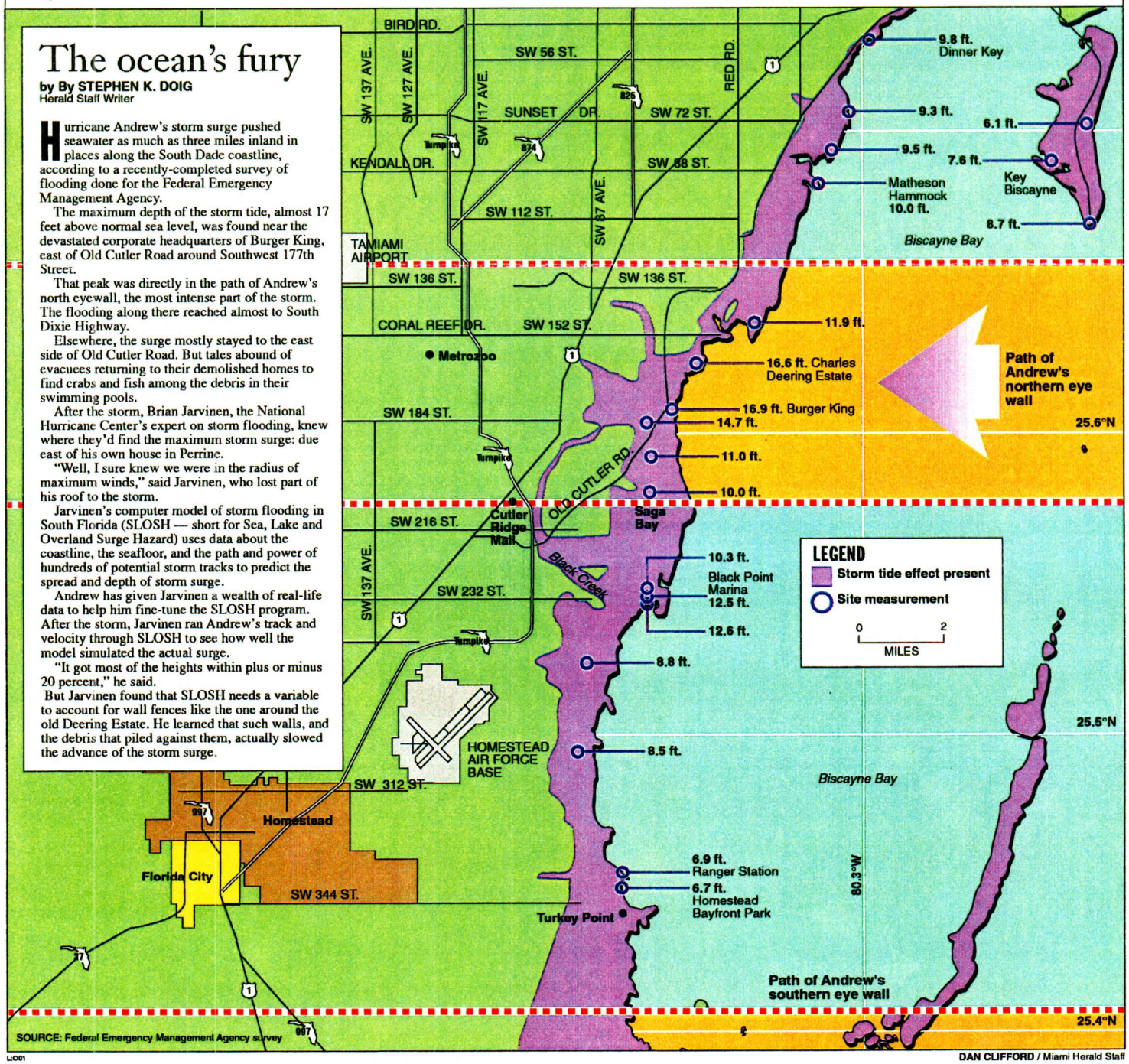
"Well, I sure knew we were in the radius of maximum winds," said Jarvinen, who lost part of his roof to the storm.

Jarvinen's computer model of storm flooding in South Florida (SLOSH — short for Sea, Lake and Overland Surge Hazard) uses data about the coastline, the seafloor, and the path and power of hundreds of potential storm tracks to predict the spread and depth of storm surge.

Andrew has given Jarvinen a wealth of real-life data to help him fine-tune the SLOSH program. After the storm, Jarvinen ran Andrew's track and velocity through SLOSH to see how well the model simulated the actual surge.

"It got most of the heights within plus or minus 20 percent," he said.

But Jarvinen found that SLOSH needs a variable to account for wall fences like the one around the old Deering Estate. He learned that such walls, and the debris that piled against them, actually slowed the advance of the storm surge.



SOURCE: Federal Emergency Management Agency survey

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DAN CLIFFORD / Miami Herald Staff

both National Hurricane Center staff and local emergency management directors. Fortunately, emergency management directors took prudent early actions and kept in constant communication with the National Hurricane Center so that they still had time to carry out appropriate evacuations for a more intense storm scenario. Ed Rapaport of the National Hurricane Center in his preliminary forecast and warning critique of Andrew, noted the following:

> *Andrew reached hurricane strength on the morning of 22 August, thereby becoming the first Atlantic hurricane to form from a tropical wave in nearly two years. An eye formed that morning...just 36 hours later, Andrew reached the borderline between a category 4 and 5 hurricane and was at its peak intensity...central pressure had fallen 92 mb, down to 922 mb. Andrew initially weakened over the Florida Straits and pressure rose to 941 mb. However, the hurricane rapidly reintensified during the last few hours preceding landfall on Florida. Radar, aircraft and satellite data showed a decreasing eye diameter and strengthening eyewall convection...the estimated central pressure was 930 mb at landfall near Homestead AFB at about 0905 UTC (505 AM EDT) 24 August.*

The preliminary report went on to say that the 16.9 foot storm tide is a record maximum for the southeast Florida peninsula. Even though Andrew was small and moved rather fast, rainfall totals were in excess of seven inches in parts of southeast Florida.

Concerning the forecast error, the preliminary report stated:

> *On average, the NHC errors were about 30% smaller than the current 10 year average. The most significant changes in Andrews' track were generally well anticipated and the forecast tracks generally lie close to the best track. However, the rate of Andrew's westward acceleration over the southwestern Atlantic was greater than initially forecast. In addition, the NHC forecasted a rate of strengthening that was less than what occurred during Andrew's period of rapid deepening.*

Appendix B includes the best track positions and a watch and warning summary for Hurricane Andrew.

RECOMMENDATIONS

Based on a review of the Hurricane Andrew experience and hazards/vulnerability study products previously developed the following recommendations are provided:

- Acknowledge increased levels of vulnerability to winds relative to the Saffir-Simpson Category 4-5 scenario. The old assumption that just mobile homes outside surge areas are vulnerable to winds may not be valid considering the aftermath of Andrew. Depending on construction practices/housing types, we must increase our vulnerability statistics to recognize this for a given area.

- Rework some of the SLOSH model set up for southeast Florida to recognize existing barriers and impedance to storm surge inland flooding.

- Remap revised SLOSH output in an easier to use and more legible format. Surge atlases should be brought up to current State of Florida/FEMA/Corps standards which includes standardized shades of blue for water bodies versus the Category 1 flood area. The Dade atlas must be simplified - too many storm categories/tracks were depicted and color choices and quality were not up to current atlas production standards. A good digitized base map of Dade County with accurate topological features/elevation data must be obtained and used for CADD production.

- Local officials must be reminded that <u>one</u> hurricane will not produce the inland extent of flooding shown in the atlases. The point(s) of maximum effect will be a function of storm size and point of landfall.

- Future study updates for regions in the peninsula part of Florida should give further consideration to exiting or crossing storm tracks and what effects they might have on a community.

Chapter 3

Evacuation Behavior in Hurricane Andrew in Southeast Florida

(Prepared by Hazards Management Group)

Evacuation studies include assumptions about how the public will respond during a hurricane evacuation, and two such reports were produced for the Jacksonville District of the Corps for southeast Florida. Separate analyses were conducted for Monroe County (Nelson, Crumley, Fritzsche, and Adcock, 1989) and Palm Beach, Broward, and Dade Counties (Hazards Management Group, 1990). An earlier study was performed for the entire region in 1983 (Post, Buckley, Schuh, and Jernigan, 1983). This report describes how the public in southeast Florida actually responded during the hurricane Andrew evacuation and how that behavior compared with the projections made in the 1989 and 1990 behavioral analyses used in preparing evacuation studies for the region. Descriptions of public response in Andrew come primarily from a preliminary analysis of data collected in a Florida State University study funded by the National Science Foundation (Baker, 1993). The Florida State University study included a telephone sample survey of 900 residents of Broward, Dade, and Monroe counties, plus 400 in southwest Florida not included in this report. That data is supplemented in this report with 200 additional telephone interviews in southeast Florida conducted by Hazards Management Group, Inc. with funding from the U.S. Army Corps of Engineers.

The combined southeast Florida post-Andrew sample of 1100 was divided among the risk areas used for evacuation operations in each of the three counties. The breakdowns and aggregations used below reflect that stratification but also reflect the necessity of combining subsamples in order to have groups of sufficient size to yield reliable findings.

All samples are subject to error because they do not include the entire population. They are estimates of the true population values, and larger samples will usually be closer to the actual population values than smaller samples. Readers should keep in mind that the figures reported as responses in Andrew are the best available estimates but remain

estimates. In general, the figures reported will be within 5 to 10 percentage points of the actual population values.

Evacuation Rates

Response in Andrew

Broward and Dade. The percentage of residents who evacuated (i.e., left their homes to go someplace they believed would be safer) in Andrew varied by proximity to the shoreline. In Broward county 69% left from the Category 1-2 surge zone, and in Dade 71% left from the Category 1 area. In the Broward Category 3 and Dade Category 2-3 zones 63% evacuated, and in Category 4-5 zones 46% left from Broward and 33% left from Dade. In both counties 13% evacuated from inland areas beyond the Category 4-5 surge limits. Had Andrew's track been slightly farther north, a significant number of homes that were not evacuated would have been flooded.

Monroe. Evacuation from the Florida Keys (Monroe County) decreased from north to south and was lower than that from the Broward and Dade high-risk areas. In the Upper Keys 62% left, compared to 45% in the Middle Keys, 40% in the Lower Keys north of Key West, and 25% in Key West. If Andrew's track had been farther south, many homes in the Keys that were not evacuated would also have been flooded.

Hypothetical Responses

The 1989 and 1990 southeast Florida behavioral studies conducted telephone interviews with residents asking how they would respond to hurricane threats. Their answers are referred to as hypothetical or intended responses.

Broward and Dade. In Broward and Dade counties, the sample was divided into "beach" and "mainland" groups. The beach sample was the same as the Category 1-2 population in Broward and the Category 1 population in Dade, although the Category 1-2 area of Broward also included a mostly narrow strip of mainland bordering Biscayne Bay. The mainland sample in the hypothetical survey was comparable to the Category 3 population in Broward county and to the Category 2-3 population in Dade.

Only nine percent of the beach respondents of either county insisted they wouldn't evacuate if ordered, implying an evacuation rate of 91%. On the mainland 11% of the Broward and 15% of the Dade samples said they wouldn't leave if ordered, indicating evacuation rates of 89% and 85% respectively.

Monroe. The Monroe county hypothetical response survey sample was divided into three zones: Upper, Middle, and Lower Keys. In the Upper Keys 78% said they would leave, versus 76% in the Middle Keys, and 56% in the Lower Keys.

Behavioral Projections

Broward and Dade. The behavioral analysis performed for Broward and Dade counties by Hazards Management Group did not attempt to provide a single global evacuation rate for the region, for an entire county, or even for a risk zone within a county. The report contained a look-up table indicating the evacuation rate that would ensue in two different storm scenarios, for three different risk zones, for mobile homes and for housing other than mobile homes. An accompanying narrative gave guidelines for further refining the values.

The report said that in a severe storm like Andrew if public officials ordered evacuation in high and moderate risk areas *and were successful in communicating to people that they need to evacuate*, 90% would leave from high-risk areas, 80% from moderate-risk areas, and 30% from areas outside the zones told to evacuate for flooding. The report specified the notice dissemination modes required to achieve those evacuation rates and stated that actual rates would be at least 25 percentage points lower if the orders weren't disseminated by officials going physically into the areas being told to evacuate.

Although only 70% evacuated from the high-risk areas of Broward and Dade in Andrew, many residents (44% in Broward and 28% in Dade) said they didn't hear from officials that they were supposed to leave. Of those who said they did hear officials say that they were to evacuate, only slightly more than half believed the notice was mandatory.

Overall, only 32% in Broward Category 1-2 and 42% in Dade Category 1 evacuation zones believe they were ordered to evacuate.

Of those who indicated that officials told them to evacuate, 80% did, compared to only 52% of those who said they weren't told to leave. Of those who understood that they were *ordered* to leave, 87% did so, and of the respondents who said that officials actually came into their neighborhood making announcements that they *must* evacuate, 89% left. The look-up table in the behavioral analysis was extremely accurate for the high-risk area.

The evacuation rates from the Broward Category 3, Dade Category 2-3, and both Category 4-5 zones were also anticipated, given the manner in which evacuation orders were perceived by residents. In Dade and Broward counties combined, 80% of the residents in these areas who believed officials had ordered them to leave complied.

Evacuation from the wind-only zone is more difficult to compare, because the behavioral analysis didn't address it in the same detail as the surge-prone areas. The behavioral analysis did not specifically state how far inland the "low-risk" area extended, how evacuation would vary within the zone as a function of proximity to the coast, or how response would be affected by variation in the success of evacuation from surge zones. Taken at face-value, however, without the benefit of guidelines for further interpretation, the look-up table overstated evacuation from the wind-only areas of Broward and Dade.

Not enough mobile homes were included in the Broward and Dade post-Andrew study to permit a statistically reliable comparison with the behavioral analysis. Available data as well as anecdotal evidence appear consistent with the look-up table, however. In a number of the most devastated mobile home parks in south Dade county, some of the residents did not leave and had to seek refuge in clubhouses on site.

Monroe. Strictly speaking, the behavioral analysis for Monroe county did not make explicit projections of response: it simply reported the telephone survey hypothetical responses. Because the purpose of the report was to provide behavioral assumptions for

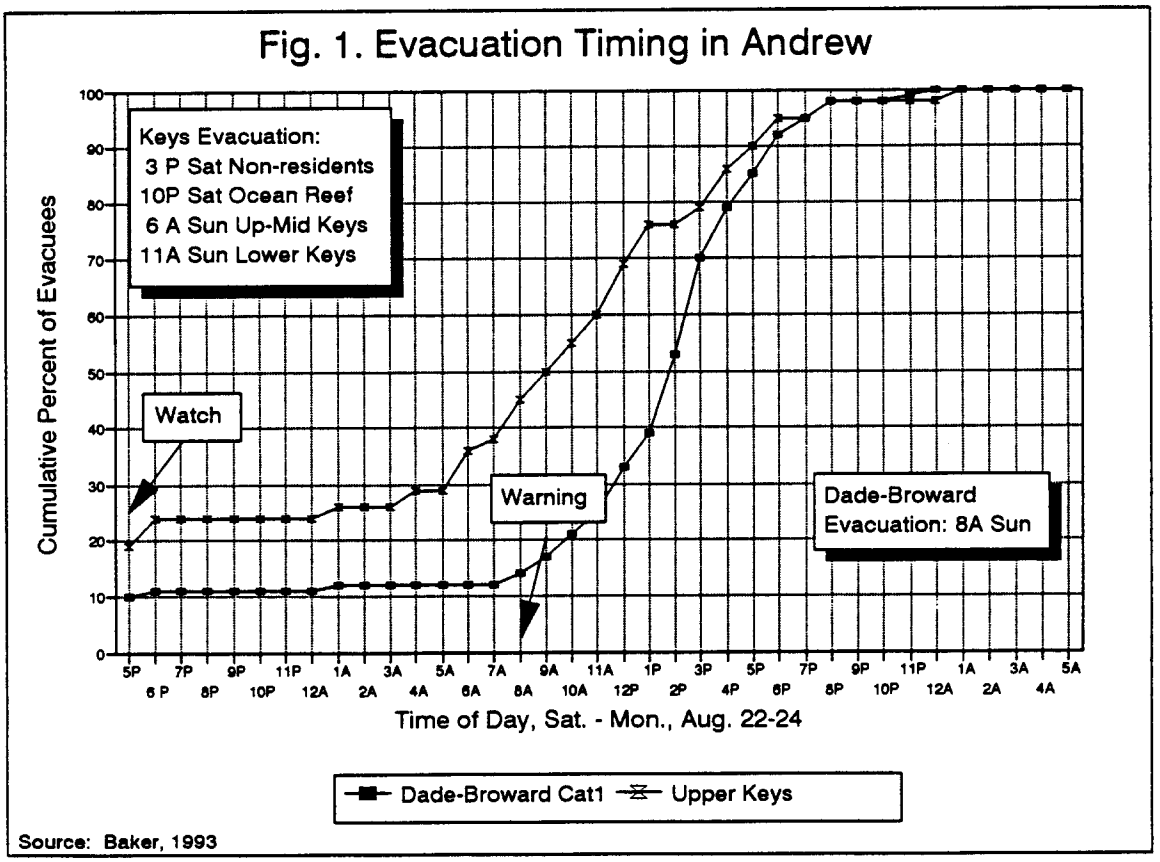
evacuation planning, however, it is reasonable to assume the authors intended that the survey results be used for planning.

The behavioral analysis overpredicted actual response in the Upper (78% predicted vs. 62% actual), Middle (76% vs. 45%), and Lower Keys (56% vs. 29%). The survey scenario yielding the predictions specified a Category 3 hurricane, with officials ordering evacuation.

Evacuation Timing

Response in Andrew

Figure 1 depicts the cumulative evacuation rate from 5 PM Saturday, August 22, when a hurricane Watch was first issued for southeast Florida, to 5 AM Monday, August 24, when landfall occurred. The curves indicate, of all eventual evacuees, the cumulative percentage who had left at various times and dates.



Broward and Dade. Ten percent of the evacuees from the Dade and Broward high-risk areas said they had already left when the Watch was issued. Few others left during Saturday evening and night, so that when a Warning was issued the following morning, less than 15% of the eventual evacuees had left. At that time officials in both Broward and Dade counties issued evacuation orders. The evacuation rate clearly began to increase around 8 AM Sunday, and by 2 PM that afternoon slightly more than half the evacuees had left. By 6 PM over 90% of the evacuees had left. Response curves for lower risk areas of Broward and Dade were comparable but lagged slightly behind the curve for the highest risk zones.

Monroe. The evacuation was phased in the Florida Keys. Saturday afternoon at 3 PM state and county parks were closed, at 4 PM officials began recommending that non-residents leave, at 6 PM tourists were ordered out, at 10 PM that evening the Ocean Reef development near the northern extent of the Upper Keys was told to evacuate, at 1 AM RV parks and campgrounds were evacuated, and at 2 AM Sunday mobile home parks in the Upper Keys were told to leave. At 6 AM Sunday morning an evacuation order was issued for all of the Upper and Middle Keys, followed at 11 AM by an order for the Lower Keys. Although most residents weren't told to leave until early Sunday morning, many were aware of the other evacuation activities going on earlier and some were probably influenced.

Twenty percent of the evacuees said they had already left when the hurricane Watch was issued, and another 10% left by Sunday morning when the general evacuation order was issued for the Upper Keys. The response curve began to increase sharply at that time, and by 9 AM 50% of the evacuees had left. By 5 PM 90% of the evacuees had left, and officials halted evacuation out of the Keys from the Upper Keys at 6 PM. Response curves for the Middle and Lower Keys were similar but somewhat later.

Hypothetical Responses.

Broward and Dade. Residents were presented with a hypothetical threat scenario in which a category 3 hurricane threatened, a Watch was in effect, and officials had not

advised any actions. Half the beach respondents and a third of the mainland respondents said they would evacuate under those conditions (but were not asked whether they would necessarily leave right away).

Monroe. The Monroe hypothetical response survey presented three category 3 storm threat scenarios: a Watch 36 hours before possible landfall, with officials recommending voluntary evacuation; a Warning 24 hours before possible landfall, with officials ordering evacuation; and a Warning 12 hours before possible landfall, also with officials ordering evacuation. When respondents indicated they would evacuate in one of the scenarios, they then were asked how long it would take before they actually left.

The responses were combined to produce a logarithmically-shaped cumulative response curve for the Upper Keys in which more than 20% of the evacuees left within one hour of the Watch + recommendation scenario, 60% of the evacuees left after the watch + recommendation *before* the Warning + order, and 90% of the evacuees left prior to the 12-hour-before-landfall notice. Averaging over the three scenarios, 30% of the respondents said they would leave immediately after the notice, 61% within three hours of the notice, and 81% within six hours.

Behavioral Projections

Broward and Dade. The behavioral analysis report stated that the early response indicated by the survey scenario was unrealistic, noting that relatively few evacuees (less than 20%) leave before an evacuation notice is issued. The report stated that actual response timing will depend upon the urgency of the evacuation and proposed three different logistic ("S") curves for planning. One curve supposed early, very aggressive, effective action by officials in which 10% of the evacuees left before the evacuation order was issued and 90% of the evacuees would leave within six hours of the time the order was issued, and reaching that point six hours before arrival of the storm (tropical storm winds). Another curve supposed a late, urgent evacuation, stemming from an unanticipated change in storm track or forward speed. It specified that 20% of the evacuees would have left

before the evacuation order was issued, and then within five hours a total of 90% of the evacuees would have left, leaving just one hour before the arrival of the storm.

The Andrew evacuation was most like the "normal" scenario proposed in the behavioral analysis report. The normal timing scenario presumed that warning time was adequate for a relatively unhurried evacuation and that officials did not convey a sense of urgency to leave right away. It specified that only 10% of the evacuees would have left before an order, and the cumulative evacuation rate would climb almost linearly over the next 10 hours when 90% of the evacuees would have left, three hours before arrival of storm conditions.

In Andrew approximately 15% of the evacuees from high-risk areas in Broward and Dade left before the order was issued (compared to 10% in the behavioral analysis). Ninety percent of all evacuees had left within 10 hours of the order (compared to 10 hours in the behavioral analysis). The 90% level was reached at 6 PM Sunday, which was at *least* six hours before the arrival of tropical storm conditions (compared to three hours in the behavioral analysis). Thus the normal response scenario in the behavioral analysis was very close to the response in Andrew, except that the actual evacuation was concluded earlier.

Monroe. The Andrew evacuation in the Keys is not perfectly comparable to the scenario sequence proposed in the behavioral analysis report because in Andrew residents in general were not advised to evacuate when the Watch was issued. However, given the other sort of evacuation activities which took place prior to the Watch, and given the evacuation notices issued for parts of the Upper Keys before the general evacuation order, one might argue that actions by officials at the time of the Watch provided cues which were tantamount to recommending voluntary evacuation. *If* that is true, then the behavioral analysis report specified that 70% of the evacuees would have left by the time the order was issued (compared to 36% actual in Andrew), and by noon on Sunday almost 90% would have left (compared to 70% actual in Andrew).

If the behavioral analysis report warning scenario is inappropriate for comparison to the Andrew evacuation, another comparison can be made. The report indicated that 30% of evacuees would leave within one hour of an evacuation notice, 61% (cumulative) within three hours, and 81% (cumulative) within six hours. The actual response was significantly slower.

Use of Public Shelters

Types of refuge include the homes of friends and relatives, official public shelters, hotels and motels, and a wide variety of other locations such as workplaces, churches, and second homes. For emergency management and Red Cross officials the most critical are public shelters, because it is those which must be provided for by government and the Red Cross.

Response in Andrew

Broward and Dade. Overall only 6% of all evacuees said they went to Red Cross public shelters, and there was little variation from place to place. In Broward county inland of the Category 3 surge zone, 19% of the evacuees went to public shelters. However, the total number of evacuees within the sample from that area of Broward was only 31 people, meaning that the actual percentage of evacuees using public shelters actually could be more than 10 percentage points higher or lower than the 19% figure. Non-whites (13%) were more likely to use public shelters than whites (5%), and households with annual incomes below $12,000 were more likely to use public shelters than those with higher incomes (24% vs. 4.5%).

Monroe. Overall 8% of the evacuees in the Keys said they used public shelters. Shelter use increased from north to south, ranging from 2% in the Upper Keys, to 7% in the Middle Keys, to 16% in the Lower Keys (including Key West).

Hypothetical Responses.

Broward and Dade. Among residents in beach areas, 18% in Broward and 22% in Dade said they would use public shelters. On the mainland, 21% in Broward and 36% in Dade said they would go to public shelters. Actual shelter use was dramatically lower than the hypothetical usage rates. In hypothetical surveys the households with annual incomes from $10,000 to $25,000 had similar shelter use rates, and usage declined gradually as income rose above $25,000. Non-whites were more likely to say they would use public shelters than whites.

Monroe. In the Upper Keys 6% said they would use public shelters, compared to 12% in the Middle Keys, and 30% in the Lower Keys. The average was 15%.

Behavioral Projections.

Broward and Dade. The behavioral analysis report provided nine different shelter use scenarios based on risk area and income and also discussed how other variables such as shelter policies, actions by public officials, and race could further affect shelter use. The report, despite lowering the projections below the hypothetical response levels, still overestimated shelter use for most evacuees. It was accurate for high-income evacuees from high-risk areas and for Broward county inland of the Category 3 surge limits. The predicted inverse relationship between income and shelter use was true but weaker than anticipated.

Monroe. Actual shelter use in Monroe county was consistently below the levels stated in the behavioral analysis report: 1% actual vs. 6% anticipated in the Upper Keys, 7% vs. 12% in the Middle Keys, and 16% vs. 30% in the Lower Keys.

Evacuation Destinations

Response in Andrew

Broward and Dade. From the Broward Category 1-2 and Dade Category 1 zones 35% of the evacuees went to destinations outside their own county. In the Broward 3 and 4-5 and Dade 2-3 and 4-5 zones, 25% left their home county. There were too few evacuees

surveyed outside the surge zones to calculate reliable estimates of destination locations. The trend inland across the other zones suggests that the figure would be less than 25%.

Monroe. Reliance upon destinations outside Monroe county decreased from the Upper Keys south. From the Upper Keys 77% of the evacuees went out of county, 47% from the Middle Keys, and 29% from the Lower Keys. The overall figure was 48%.

Hypothetical Responses

Broward and Dade. Overall 35% of Broward and 41% of Dade respondents said they intended to leave their county. The behavioral analysis document did not report hypothetical survey results by risk area.

Monroe. Eighty-seven percent of intended evacuees from the Upper Keys said they would leave Monroe county, compared to 77% from the Middle Keys and 61% from the Lower Keys.

Behavioral Projections

The behavioral analysis report provided estimates for evacuees leaving their home county under two scenarios for high, moderate, and low risk areas: a very strong storm, with an early evacuation and a weak storm, with typical timing. Andrew, however, was a very strong storm, with typical timing. The appropriate values for an evacuation like Andrew's would be between the two scenarios in the report. Using these values, the report would predict evacuees leaving their own county at 43% from high risk areas, and 28% from moderate risk areas. The actual figures in Andrew were 35% for high risk areas and 25% for moderate risk areas. The behavioral analysis was close in both instances, but overstated the rate for the high risk zone by eight percentage points and understated the rate for the moderate risk zone by three percentage points.

Monroe. The behavioral analysis report used values of 87% the Upper Keys, 77% for the Middle Keys, and 62% for the Lower Keys. Actual values were 77% in the Upper Keys, 47% in the Middle Keys, and 29% in the Lower Keys. The values were close for the

Upper Keys (10 percentage points too high), but significantly worse in the Lower Keys (30 and 33 percentage points too high).

Vehicle Use

Response in Andrew

The percentage of vehicles available to evacuees which are actually used in evacuations is almost a constant, seldom being less than 65% or more than 75%. Response in Andrew generally fell within that range, accounting for sampling error. In the Broward Category 1-2 and Dade Category 1 zone 77% of the available vehicles were used, in the rest of the Broward and Dade areas 69% were used, and in the Keys 67% were used.

Hypothetical Responses

In hypothetical response surveys interviewees in the beach areas of Broward and Dade counties said they would use 71% of the vehicles available to them. Mainland residents said they would use 65% of their available vehicles. In the Keys, survey respondents said they would use 67% of their vehicles. As demonstrated in other studies, hypothetical response values for vehicle use are good predictors of actual use.

Behavioral Projections

The behavioral assumptions for Broward and Dade high-risk areas indicated that 65% to 75% of the available vehicles would be used in an evacuation. Vehicle use in Andrew was 77% in this area, slightly higher than the upper end of the projected range. The behavioral analysis report stated that 60% to 70% of the vehicles available in the mainland area would be used, and in Andrew the figure was 69%. In the Keys, the behavioral analysis reported that 67% of the available vehicles would be used, and in Andrew 65% were used.

Conclusions

Comparisons between actual response data in Andrew, hypothetical survey results, and response projections provided in behavioral analysis reports prepared for southeast Florida reaffirm two basic conclusions which have been evident for years: 1) hypothetical

response data alone should *not* be used for deriving evacuation behavioral assumptions and 2) a *variety* of assumptions should be provided for a variety of threat and evacuation scenarios, because public response will vary not only from one place to another in the same storm but from storm to storm in the same place. To our knowledge the only locations where behavioral analyses currently rely exclusively upon hypothetical response data are the Florida Keys, the east-central regional planning area of Florida, all of Georgia, and all of Texas. The approach now being used by planners in southwest Florida is unclear but appears to be a set of values developed for Lee county and applied generically without differentiation within the region.

The methodology used in preparing the behavioral analysis for Broward and Dade counties (past response data in David in 1979 + general patterns of response in evacuations elsewhere + hypothetical response surveys in Broward and Dade + adjustments indicated by past comparisons between hypothetical and actual responses elsewhere + input from local emergency management officials) yielded projections which in most instances were very close to the responses observed in Andrew. The discrepancies, however, illustrate the fact that there is still much to learn about public response in hurricanes in general and the application of generalizations to specific locations. Opportunities to further that knowledge should not be missed when evacuations occur.

Chapter 4

Shelter Issues

The primary objectives of shelter analyses prepared for FEMA/Corps comprehensive hurricane evacuation studies are to list public shelter locations, assess their vulnerability relative to storm surge flooding, and to estimate the number of people who would seek local public shelter for a particular hurricane intensity or threat. Shelter location/capacity data are obtained from local emergency management staff working in conjunction with the American Red Cross, schoolboard or other local agencies. Comparisons are then made with SLOSH data to assess flooding potential. Public shelter capacity is usually compared to public shelter demand figures generated in the transportation analysis to determine potential deficits or surpluses in sheltering. The behavioral analysis is important to this process as assumptions for the transportation analysis (regarding the percent of evacuees going to public shelter) come from the behavioral analysis or behavioral parameters recommended by the local directors.

Shelter issues related to Andrew were discussed with local and state officials. Discussions focused on the following topics:

When were shelters opened and when did evacuees arrive/stop arriving?

How many shelters were opened and how many people were sheltered?

Were any flooding, wind, or loss of power problems encountered with shelters during the storm?

Table 1 summarizes the responses to each of these topics gathered in the lower southeast Florida area counties. Table 2 is also provided showing public shelter statistics gathered for other south Florida counties responding to Andrew. Most shelters opened

TABLE 1

Lower Southeast Florida Counties
Public Shelter Data

Location	Number of Shelters Opened	Number of People Sheltered	Number of Shelters/Expected Public Shelter Evacuees - Tech. Data Report	Time Opened/Duration	Flooding, Wind or Loss of Power
Monroe County	FIU in Dade, 2 refuge in Key West	900 at FIU	No official county shelters for this storm category.	--	(See Dade County)
Dade County	47	43,000	52 shelters/75,185 people.	8/23/92 10:00 AM Half open until 9/6/92	Toilets did not work, water pressure problems, some food/water supplies not adequate, inadequate Red Cross staffing, loss of power, two shelters with major wind problems.
Broward County	39	26,440	23 shelters/62,070 people.	8/23/92 10:00 AM 3 days	Some loss of power, one shelter with roof problems.
Palm Beach County	24	6,000	50 shelters/27,400 people.	8/23/92 3:00 PM 23 hours	Loss of Power in south part of county.

TABLE 2

Other South Florida Counties
Public Shelter Data

Location	Number of Shelters Opened	Number of People Sheltered	Time Opened/Duration	Flooding, Wind or Loss of Power
Collier County	9	3,450	8/23/92 6:00 PM 20 hours	Loss of power at all shelters after 8:30 a.m.
Lee County	8	2,900	8/23/92 7:00 PM 20 hours	--
Charlotte County	4	350	8/23/92 5:00 pm 20 Hours	None
Sarasota County	4	<100	8/23/92 3:34 PM 24 Hours	None
Martin County	7	1,200	8/23/92 Noon 24 hours	None

in Dade and Broward Counties were operational by Sunday morning at 10 a.m. Palm Beach shelters were operational by Sunday at 3 p.m. No official public shelters were opened in Monroe County although it has been reported that two refuges were opened in Key West by Red Cross staff. Most shelters stayed open approximately 1 to 3 days except in the heaviest hit areas of Dade County. Approximately 20 Dade shelters stayed open for two to three weeks. Evacuees generally arrived as soon as shelters opened and continued to arrive until about 9 p.m. Sunday evening. In Palm Beach and Broward Counties, local emergency management officials were satisfied with Red Cross staffing of shelters. Some shelters experienced loss of power and backup generators were used where available. Broward County had one shelter with a roof problem - but officials were able to relocate the evacuees to another shelter.

The public shelter situation was much less optimal in Dade County. Water pressure problems at many shelters created situations where no toilets were working. Food and water supplies at some shelters were not adequate - this was especially acute at a shelter which was housing elderly evacuees from Miami Beach. Loss of power was experienced throughout the county and two shelters had major wind problems. Concerns were also expressed by the County that some shelters had inadequate or no Red Cross staff available to operate the facility.

As can be seen in Table 1, the number of public shelter evacuees in the lower southeast Florida counties during Andrew was significantly less than what was anticipated through statistics generated in study products. Local officials had fairly reliable estimates of the numbers of people in public shelters. However, estimates of the total number of people evacuating dwelling units within each county are rough at best. Therefore it is hard to confidently estimate the exact percent of total evacuees that went to local public shelters. The media roughly estimates that approximately 750,000 people evacuated dwelling units in lower southeast Florida. The Red Cross statistics indicate that about 72,000 evacuees were in in-region public shelters. This would translate to about ten percent of the evacuees going to local public shelters.

There are several important reasons why anticipated in-county shelter demand was much higher than actual demand (some of which also applied to the Hurricane Hugo situation in South Carolina in 1989):

1. Due to the publicity of the storm by the media, and the actions/ preparation taken Saturday by both private citizens and local officials, evacuees were able and certainly willing to leave the threatened counties and go northbound out of the region.

2. The technical analyses used to develop the shelter demand figures in the Technical Data Report were based on 100 percent participation rates (of people living in potential storm surge areas). Obviously, participation rates were considerably less than this particularly in the Miami Beach area. Although limited participation rates (not 100 percent) were used in the Monroe County work, it is doubtful that the assumed 60 percent of the lower Keys people responded.

3. Compared to the number of shelter locations identified for each county (in the Technical Data Report) a lesser number of shelters were opened. This was not true in Broward County where many more were opened.

4. Behavioral assumptions regarding percent going to pubic shelter were higher than the percent of evacuees that acually went to public shelters.

RECOMMENDATIONS

Based on the Andrew experience, it is recommended that future Corps/FEMA hurricane study efforts incorporate/encourage the following:

1. With the State of Florida acting as a catalyst, local officials should be encouraged to work out statewide mutual sheltering agreements with inland host areas (such as Orlando). All states should address inland sheltering requirements in their hurricane preparedness efforts.

2. Study managers should confirm with emergency management and shelter officials (e.g., Red Cross) whether all identified shelters can be opened, staffed, powered, and supplied for hurricane scenarios involving a large number of evacuees.

3. New schools/universities and public buildings should be constructed with provisions made for "safe" hurricane sheltering. The study process should provide a technical basis for evaluating the importance of major new public shelters.

4. Since Hurricane Hugo, FEMA/Corps studies have done an excellent job of checking verified first floor elevations against potential surge inundation figures. These efforts have helped to eliminate the use of shelters in potential storm surge areas. It now appears that after Andrew, new efforts must be developed to look at potential wind problems.

Chapter 5

Transportation/Clearance Time Data

In FEMA/Corps of Engineers comprehensive hurricane evacuation studies, the primary objective of the transportation analysis is to determine the clearance times needed to conduct a safe and timely evacuation for a range of hurricane threats. Information from the vulnerability, shelter, and behavioral analyses are directly input as well as various sources of permanent and seasonal population data. For the lower southeast Florida studies, regional and county clearance times were developed for two or three storm intensity groups (eg. Category 1-2, Category 3-5), several seasonal occupancy assumptions, and three rates of mobilization on the part of the evacuating population. The number of scenarios for a particular county was obviously dependent upon the inland extent of flooding and population characteristics of that locality.

Transportation and clearance time issues related to Andrew and discussed by the study team with local and state officials included the following:

Was the evacuation roadway network accurate - did evacuees use projected routes?

Were any traffic control actions taken to speed up flow?

When was the evacuation essentially completed - how long did the evacuation take?

Were any major problems encountered in this evacuation?

Table 3 summarizes the response to each of these topics gathered in the lower southeast Florida area counties. Table 4 is also provided showing statistics gathered for other south Florida counties responding to Andrew. Clearance times calculated for the

TABLE 3
Lower Southeast Florida Counties
Transportation/Clearance Time Data

Location	Evacuation Roadway Network Accurate	Specific Traffic Control Actions	Clearance Time Experienced in Andrew	Study Calculated Clearance Time	Problems Encountered
Monroe County	Yes	Traffic split Sunday 6:00 AM to Card Sound Road highway patrol aircraft used to spot bottlenecks and disabled vehicles, phased evacuation, closed state parks early.	24 hours	27 hours w/Card Sound Road diversion	No programmable signs. Plantation Key service station tie-up, Jewfish Creek bridge malfunction at 11:30 p.m. Saturday, stop and go traffic at Tavernier Road construction area, 3 stalled vehicles, traffic trying to get in left NB lane to avoid Card Sound Road. Lifting of tolls on HEFT.
Dade County	Yes	Metrobus drivers used to move 8,000 elderly and special needs.	13 hours	15 hours	None
Broward County	Yes	Bridges locked down 3-1/2 hours after evacuation order, used buses to move 5,000 people.	17 hours	23-1/4 hours	Signals shut down too early; heavy background traffic.
Palm Beach County	Yes	Tolls lifted on Turnpike at noon.	7 hours	11 hours	Major congestion on Florida Turnpike and I-95 where number of lanes NB decreases; backups at construction areas and toll plazas.

TABLE 4
Other South Florida Counties
Transportation/Clearance Time Data

Location	Evacuation Roadway Network Accurate	Specific Traffic Control Actions	Clearance Time Experienced in Andrew	Problems Encountered
Collier County	Yes	Yes, at I-75 on Ramps	14 hours	SR 27, SR 29 and US 41 northbound Under-utilized, congestion on I-75 on ramps.
Lee County	Yes	--	17 hours	--
Charlotte County	Yes	None	6 hours Mainly mobile home evac.	SR 27 under-utilized.
Sarasota County	Yes	None	16 hours	None
Martin County	Yes	None	12 hours	--

latest FEMA/Corps study generally compared well with actual times experienced in Hurricane Andrew. Monroe and Dade Counties' times were slightly less than calculated times. This was directly due to less participation on the part of Dade and Monroe residents than had been assumed in the modeling. Broward and Palm Beach Counties' times deviated from calculated times by approximately four to six hours. The significantly lower times in those counties suggest participation rates considerably below the 100 percent assumed in the original calculations. The anticipated storm track as of Sunday afternoon August 23rd may have greatly reduced Palm Beach County's participation rates and clearance times. The times also suggest that many evacuees may have left the area well in advance of the official evacuation order given early Sunday morning. Traffic counts collected from the permanent count stations that were functioning prior to and during the Andrew evacuation confirm this phenomenon.

Appendix D provides graphs of the northbound and southbound directional traffic movements during the evacuation that could be analyzed from Florida Department of Transportation permanent count stations. Previous Sundays before Sunday August 23rd are shown on the graphs for comparison purposes. For those few stations where the counters were functioning for earlier dates as well as through most of the evacuation, the data is extremely interesting. The graphs show some evacuation taking place even before 6:00 a.m. on Sunday in Dade, Broward and Palm Beach Counties, but they show an immediate more pronounced response as soon as the official evacuation order took effect. Peak traffic flow occurred in the early to mid-afternoon period.

The graphs (as implied by the southbound traffic) confirm previous assumptions made about how background traffic diminishes as the evacuation traffic continues over time. Observations during the evacuation by Captain Grady Carrick and his staff at the Florida Highway Patrol as well as local Sheriffs in each county coincide well with the traffic count data that was available.

Table 3 provides special traffic control/transportation actions that each county implemented for the evacuation. Most notably, Monroe County phased its evacuation by

evacuating the tourists and day visitors people on Saturday afternoon and evening. Voluntary evacuation of Monroe county permanent residents started Saturday as well. When the official evacuation order (for permanent residents) was issued for early Sunday morning, those remaining residents north of the Seven-Mile bridge began moving first. Lower Keys residents were then asked to evacuate later in the day. Evacuation was cut off in the early evening so that late leaving evacuees would not run the risk of being caught in pre-landfall severe weather conditions. Due to the need to get traffic out more quickly than the 18 mile stretch of U.S. 1 could handle, a portion of traffic was directed up to Card Sound Road beginning Sunday at 6:00 a.m. Since the Ocean Reef residents had been evacuated early on, there were little or no turning conflicts to deal with at CR 905 - Card Sound Road intersection.

Dade and Broward counties relied on buses and their drivers to move many elderly and special needs groups to shelter. Although some drivers did not show up for duty, those drivers who did assist Miami Beach residents were considered to be real heroes by local officials. Where appropriate, drawbridges were locked down to facilitate the evacuation.

Although most individuals and officials felt that the evacuation went well and that traffic moved as expected, there were complaints of traffic tie-ups on the Florida Turnpike at toll plazas that were still operating until 1:00 p.m. Sunday. Construction sites on I-95 and the Turnpike created some congestion as well. A few individuals in Monroe County wrote complaints about traffic stopping on U.S. 1 throughout the Keys. This may have related to congestion caused by three stalled vehicles and road construction sites near Tavernier. Despite the expected levels of congestion it appears that traffic control officers did an exceptionally good job during the Andrew evacuation. It is also apparent that local emergency management officials took seriously the clearance time data that had been provided in study products.

RECOMMENDATIONS

Based on the Hurricane Andrew experience, it is recommended that the following items be considered for future study efforts:

1. Enlarge the study area boundaries to include all regions in south Florida whose traffic and sheltering needs will impact each other. Other states with multi-regional evacuation traffic impacts must have a plan to deal with these potential problems.

2. Restudy the lower southeast Florida area to include new land use distribution and increased participation percentages for residents in non-surge areas.

3. Encourage officials to lift the tolls on appropriate facilities as soon as a hurricane warning is posted for southeast Florida counties or any area serviced by toll roads.

4. Encourage the use of variable message signs that keep motorists informed of traffic, storm, and sheltering information particularly as they approach in-land areas such as Orlando. Radio stations/EBS could broadcast current information.

5. Encourage appropriate officials to have traffic counters operational on U.S. 1 out of the Keys so that the flow of evacuation traffic out can be monitored and analyzed. Other areas should also be counted to calibrate/validate evacuation data.

6. Study the potential savings in clearance time by reverse laning certain local and regional highway facilities - likewise address opportunities and constraints that relate to implementing such measures.

7. Keep traffic signals functioning as long as possible so that law enforcement officials are not consumed totally with traffic control. Signals should be set to facilitate traffic flow as appropriate.

8. Use more cones to separate U.S. 1 and Card Sound Road diverted traffic in the north part of Monroe County to avoid last minute lane changes and merging conflicts.

9. As appropriate, run more scenarios with smaller percentages of people going to in-county shelters.

10. Run additional scenarios with larger percent of non-surge evacuees evacuating based on potential behavioral trends related to Andrew and Hugo.

Chapter 6

Evacuation Decision Making

Some of the most important products developed as a part of the FEMA/Corps of Engineers hurricane evacuation studies and delivered to local and state officials have been evacuation decision making tools. These tools are decision arc maps and tables as well as computer software such as HURREVAC. These products graphically tie together real-time storm characteristics with clearance time data. Their purpose is to give emergency management directors a means of retrieving Technical Data Report information without having to dig through a report during an emergency. Evacuation decision tools provide guidance and assistance to decision makers as to when an evacuation should begin relative to a specific hurricane, its associated wind field, forward speed, probabilities, forecast track, and intensity.

Discussions initiated by the FEMA/Corps study team with local and state officials regarding the evacuation decision process focused on the following questions:

When was the Emergency Operating Center fully activated and what prompted this decision?

What study products/decision aides were used to decide when to evacuate and who should evacuate?

When was the evacuation order or request made?

Table 5 summarizes the responses to each of these topics gathered in the lower southeast Florida counties. Table 6 provides decision making information gathered for other south Florida counties responding to Andrew.

As shown in the tables, most EOCs were fully activated Saturday evening or early Sunday morning. Partial activations had occurred in most of the counties by Saturday

TABLE 5

Lower Southeast Florida Counties
Evacuation Decision Process

Location	Time EOC Was Fully Activated	What Prompted Decision to Activate	What Study Products Decision Aids Were Used in Deciding When and Who Should Evacuate	Time of Evacuation Order	How Well Study Products Work
Monroe County	2:00 AM 8/22/92	Clearance times/NHC Data	Decision Arcs - NWS ran HURREVAC	6:00 AM 8/23/92*	Well
Dade County	6:00 AM 8/23/92	NHC Information	Surge Maps, GDS, Decision Arcs, Zip Code Vulnerability	8:00 AM 8/23/92	Some Concerns About HURREVAC and Surge Atlas
Broward County	6:00 PM 8/22/92	Storm Information	HURREVAC Model, Surge Maps, Zone Map	7:00 AM 8/23/92	Well
Palm Beach County	10:00 AM 8/23/92	Hurricane Warning	GDS, Draft Quads, HURREVAC Model	3:00 PM 8/23/92	Very Well

*Permanent residents evacuation ordered.

TABLE 6

Other South Florida Counties
Evacuation Decision Process

Location	Time EOC Was Fully Activated	What Prompted Decision to Activate	What Decision Aides Were Used in Deciding When and Who Should Evacuate	Time of Evacuation Order	How Well Existing Products Work
Collier County	4:15 PM 8/22/92	Acceleration & Intensification	Decision Arcs, GDS, SLOSH Atlas, NHC Forecast Discussions	8:00 a.m. 8/23/92 recommended 2:00 PM 8/23/92 mandatory	Very Well
Lee County	5:30 PM 8/22/92	Storm Information	NHC Forecasts, GDS, REsponse Storm Worksheet Surge Maps Vulnerability Data	3:00 PM 8/23/92	Well
Charlotte County	6:00 AM 8/23/92	Storm Information	Surge Maps, Decision Arcs, NHC Forecasts	4:00 PM 8/23/92	Well
Sarasota County	8:00 AM 8/23/92	Storm Information	Surge Maps, Decision Arcs, SLOSH Model	2:30 PM 8/23/92	Well
Martin County	6:00 PM 8/22/92	Acceleration & Intensification	GDS, Decision Arcs	10:00 AM 8/23/92	Well

afternoon August 22nd. Emergency management directors communicated with county department heads on Saturday so that they would be ready to respond once the EOC became fully operational and the evacuation initiated. Most emergency management officials accelerated their early response actions based on discussions with National Hurricane Center staff indicating that Andrew had increased its intensity and forward speed.

Local officials seemed pleased with the way study products performed and found the surge and evacuation zone mapping, decision arcs, and HURREVAC quite helpful. Many communities relied upon GDS (a program developed by Hazards Management Group) and found it also to work well. Dade County used GDS but not HURREVAC during Andrew.

Evacuation orders were released early Sunday morning and correspond with hurricane warnings that were issued by the National Hurricane Center as well as time requirements for carrying out a safe and orderly evacuation (as indicated by specific clearance times that were incorporated into the decision making tools). Monroe County set the order for six a.m. Sunday morning, having moved many of the tourists and daytrippers as well as some permanent residents on Saturday afternoon and evening. Florida Highway Patrolmen observed a steady stream of traffic leaving the Keys early Sunday morning between midnight and 6 AM before the order was given. The use of Card Sound Road for diverted U.S. Highway 1 traffic also allowed the county to wait until Sunday morning to issue the order.

Broward and Dade Counties' evacuation orders were prompted by the National Hurricane Center's warning. Because of its lower clearance time requirements, Palm Beach County was able to wait later in the day on Sunday to issue the order.

RECOMMENDATIONS

Products being provided by FEMA/Corps hurricane studies regarding evacuation decision making seem to be working well. Officials like the ability to show decision makers a "computerized" data base that ties together Technical Data Report information. A

recommendation which was previously discussed in Chapter 2, is easier to read surge mapping and zone maps at a larger more detailed scale. Excellent working relationships between local emergency directors and NWS staff is important to good decision-making. Local officials should be encouraged to continue to develop these relationships with NWS staff.

Chapter 7

Public Information

Although not a major part of previous FEMA/Corps of Engineers hurricane evacuation study efforts, public information is becoming recognized as an important final element that must be addressed. Study products and data must ultimately be tailored to a format that the media and general public can understand so that correct evacuation decisions and preparations can be made at the household level. Andrew (like Hugo) provided a glimpse of the current means of getting hurricane evacuation information into the hands of the general public. Andrew also provided local and state officials with an opportunity to assess additional needs regarding to public information.

Methods used in south Florida to inform the public in Andrew included the following:

1. Public information brochures were developed and widely distributed early in the season showing vulnerable areas, evacuation levels, and tips on hurricane preparedness. Dade and Broward Counties are good examples of these. Palm Beach County printed its brochures in three languages - English, Spanish and Creole.

2. Press briefings with national and local media to insure that they (radio, TV, newspapers) disseminate consistent information to the public - Media were given packets of hurricane materials early in the season by some emergency officials.

3. Law enforcement officials drove through neighborhoods with sirens and p.a. systems to encourage people to evacuate - this technique was used in some beach communities - some officials went door-to-door (e.g., Ocean Reef Community in Monroe County).

4. Some communities were able to provide evacuation information to the public through printed information in the local phone book.

5. An important means was through radio and television - some communities used cable TV overrides to alert the public of evacuation advisories.

6. The Weather Channel was praised by local emergency management staff for its job in public education and information.

7. Early in the season, meetings had been held with civic groups (e.g., Miami Beach) at which local emergency directors made presentations on hurricane preparedness including wind and flooding potential.

8. Mobile home park/managers were phoned to make sure they understood the threat.

9. In southwest Florida at least one county made use of flash cards/coloring books that educated school children on hurricane preparedness.

10. During the Andrew situation, Bryan Norcross of Channel 4 TV, Miami broadcast public information through the night to local residents. Channel 10 enhanced their public information activity with signing for deaf viewers.

RECOMMENDATIONS

In discussions with media representatives in the Miami, Florida market and with all of the local and state emergency officials, the following ideas and resources were identified as needs in the area of public information.

- More camera ready/computerized mapping of surge areas, routes, and shelter locations for media (must be able to update shelter information at least yearly).

- Computerized "billboard" only available to media via modem - emergency officials would provide notices and information through this.

- Need to address Emergency Broadcast System (EBS) operation - many officials are unhappy with it contending that it is out of date and more geared for nuclear emergencies.

- Need more phone lines/staff for public to call into EOC's for information - Dade County expressed major concerns with this.

- Prepare newspaper supplement in advance that could be inserted a day before projected hurricane landfall.

- Enhance phone book materials and inserts that can be used in a real time event.

- Produce canned videos for TV's to broadcast.

- Provide more local information (surge heights imposed on pictures of local landmarks) to get public attention.

- Install uniform evacuation route signs.

- Put up variable message signs giving inland shelter/EBS station information.

- Need more funding sources for printing and distributing county brochures.

- Press tends to go where the most action is - this resulted in little media coverage of Monroe County and left many wondering what was going on and what happened there. Need to have an EOC facility in Monroe County that can better accommodate media interests.

APPENDIX A

Meeting Attendees/Persons Providing Input in Affected Areas

Arnold, Gary	Collier County EM
Baker, Michele	Metro Dade Emergency Management
Balfour, Robert A.	National Weather Service (SW Fla.)
Boyer, Steve	WPLG-CH-10
Carrick, Grady	Florida Highway Patrol
Coats, Lisa	Ocean Reef Public Safety
Conley, Edward	FEMA - JIC
Davis, Marvin	FEMA - JIC
Eans, Andrew C.	Monroe County Emergency Mgt.
Elsroth, Walt	Lee Emergency Management
Esper, Todd K.	DeSoto County Emergency Management
Feagan, Gregg	Sarasota County EM
Floyd, Bill	Lee County Red Cross
Gavin, Joe	US Army Corps of Engineers - Philadelphia PA
Hahn, Christy	Congressman Porter Goss
Hale, Kate	Metro Dade Emergency Management
Henderson, Win	FEMA PIO
Henize, Dennis	NAT WEA Svc.
Kennedy, B.T.	Palm Beach EOC Emerg. Mgmt. Director
Kennington, Judi	Hendry County Emergency Management
Kerley, George	Monroe County Emergency Comm.
Koneval, R.W.	Charlotte County EM
Lange, Sgt. Mel	Broward County Sheriff's Office
Leonard, Cheryl	Broward EPD
Lewis, Don	PBS&J
London, J.G. "Joe"	Monroe County Fire Marshall
Mappes, Leon	Charlotte County Chapter - ARC
Martens, Brian	Ocean Reef Public Safety
Massey, Bill	FEMA - Atlanta
McDonald, Michael	Florida - DCA/DEM
McDuffie, A.	U.S. Army Corps of Engineers - Wilmington, NC
Meyer, Charles	WIOD Radio
Mulhall, Tom	Monroe Emergency Mgmt./Florida EOC MIS/Systems
Murphy, Fred	Pasco County Dis. Prep./FEPA
Nave, Bob	Florida DCA/Division of Emerg. Mgmt.
Ogle, Jim	WTVJ
Owens, Earl	DeSoto County RACES MARS - ARES ECA
Pelham, Bo	Clewiston Emergency Management
Pineau, Ken	Collier County Emergency Mgt.
Pray, David F.	Charlotte County Chapter - ARC
Putnam, Don	Charlotte County Chapter - Red Cross
Quingly, William F.	Sarasota County Emergency Management
Reitman, Sy	US Army Corps of Engineers - Atlanta
Sallade, Wayne P.	Charlotte County EM
Sanchez, Virginia	Dade County Communications
Saniter, David	Lee County Emergency Management

Shermean, Dick	Collier County Red Cross
Smith, Charles	ARC Highlands Co.
St. Amand, Art	Broward EPD
Tipton, Royce	US Army Corps of Engineers - Jacksonville
Trescott, Dan	Southwest Fl. RPC
Varcinas, Paul V.	Ocean Reef Public Safety
Vergara, Hernando	Metro Dade Emergency Management
Wagner, William A., III	Mid Keys EM Deputy Fire Marshall
Wagner, Billy	Monroe County EM
Watsow, Jack	Monroe County Fire Department
Wendling, Thom	Sanibel PD
Werner, Robert D.	DeSoto County RACES & ARES ECA
Westall, Rod	Florida DCA/Division of Emerg. Mgmt.
Wilson, John	Lee County Emergency Management

APPENDIX B

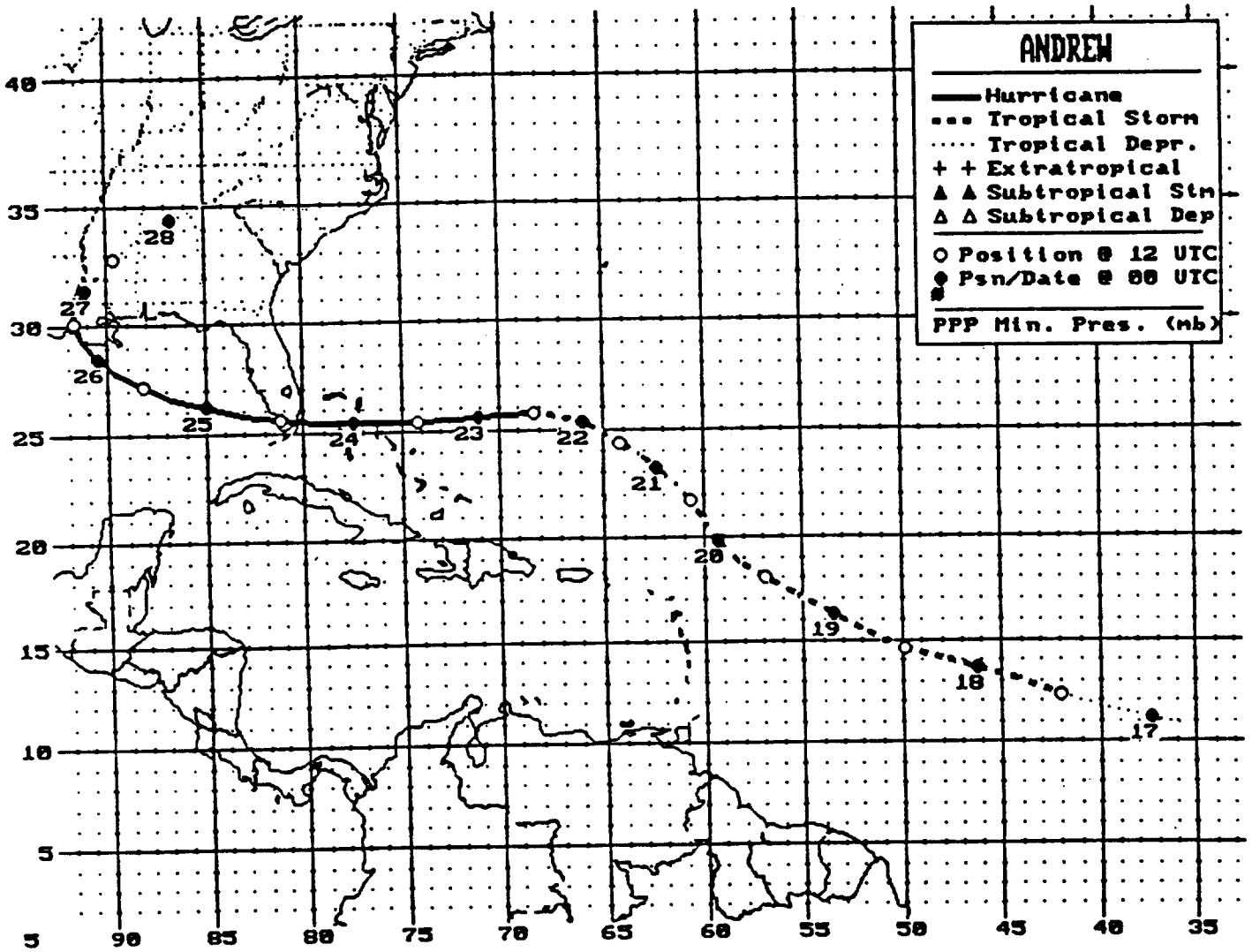
National Hurricane Center's
Hurricane Andrew Warning Summary/Timetable

Watch and Warning Summary, Hurricane Andrew, August 1992

date/time (military/EDT) action	
22/1100 Hurricane Watch	Northwest Bahamas from Andros and Eleuthera Islands Northward through Grand Bahama and Great Abaco
22/1700 Hurricane Warning	Northwest Bahamas from Andros and Eleuthera Islands Northward through Grand Bahama and Great Abaco
22/1700 Hurricane Watch	Florida East Coast from Titusville Southward through the Florida Keys including Dry Tortugas
23/0200 Hurricane Warning	Central Bahamas including Cat Island, Great Exuma, San Salvador, and Long Island
23/0800 Hurricane Warning	Florida East Coast from Vero Beach Southward through the Florida Keys to the Dry Tortugas including Florida Bay
23/0800 Tropical Storm Warning	Florida East Coast North of Vero Beach to Titusville
23/0800 Hurricane Watch	Florida West Coast South of Bayport including the greater Tampa area to north of Flamingo
23/1400 Hurricane Warning	Florida West Coast South of Venice and Lake Okeechobee
23/1400 Tropical Storm Warning	Florida West Coast North of Venice to Bayport
24/0500 Hurricane Warning Discont.	Bahamas except for Bimini and Grand Bahama
24/0900 Hurricane Warning Discont.	Remainder of the Bahamas
24/0900 Hurricane Warning Discont.	Florida Except for Lake Okeechobee and the West Coast South of Venice to Flamingo

Watch and Warning Summary, Hurricane Andrew, August 1992

date/time (military/EDT) action	
24/0900 Hurricane Watch	Northern Gulf coast from Mobile, Alabama to Sabine Pass, Texas
24/1400 Hurricane Warning Discont.	Remainder of Florida
24/1700 Hurricane Warning	Northern Gulf Coast from Pascagoula, Mississippi to Vermillion Bay, Louisiana
25/0500 Hurricane Warning	Vermillion Bay, Louisiana to Port Arthur, Texas
25/0500 Hurricane Watch	West of Port Arthur through High Island, Texas
25/1100 Hurricane Warning	West of Port Arthus through the Bolivar Peninsula, TX
25/1100 Hurricane Watch	West of the Bolivar Peninsula to Freeport, Texas
26/0300 Hurricane Warning Discont.	East of Grand Isle, Louisiana
26/0700 Hurricane Watch Discont.	West of the Bolivar Peninsula
26/0700 Hurricane Warning Discont.	West of Port Arthur, Texas
26/0900 Hurricane Warning Discont.	West of Cameron, Louisiana
26/1300 Hurricane Warning Discont.	Remainder of Gulf Coast



Best track positions for Hurricane Andrew.

APPENDIX C

Hurricane Andrew Response Questionnaire

HURRICANE ANDREW
RESPONSE QUESTIONNAIRE

To refresh your memory about dates and times, on Saturday August 22 hurricane Andrew began to look like it could hit south Florida. At 5 p.m. on Saturday evening the National Hurricane Center issued a Hurricane Watch for the east coast of Florida. At 8 a.m. the following morning -- i.e., Sunday morning -- the Hurricane Center issued a Hurricane Warning. Landfall occurred early Monday morning, around 5 a.m.

1. Were you in the area (i.e., not out-of-town) when Andrew began to threaten this area?

   IF NO, ASK IF ANYONE ELSE IN THE HOUSEHOLD WAS PRESENT AND ASK TO SPEAK TO THEM. IF NO ONE IN THE HOUSEHOLD WAS PRESENT, TERMINATE THE INTERVIEW.

   IF YES, BEGIN WITH QUESTION 2.

2. I'd like to ask you about when Andrew threatened this area -- that is, on Saturday August 22 or Sunday the 23rd. Did you leave your home to go someplace safer before the hurricane?

1	No (GO. TO Q. 3)
5	Yes (GO TO Q. 4)
7	Other(_____) Specify
9	Don't Know

3. What made you decide not to go anyplace else?

   CODE UP TO 3 RESPONSES ... THEN GO TO Q. 14.

01	Storm not severe/house adequate
02	Officials said evacuation unnecessary
03	Media said evacuation unnecessary
04	Friend/relative said evacuation unnecessary
05	Officials didn't say to evacuate
06	Probabilities indicated low chance of hit
07	Other information indicated storm wouldn't hit
08	Had no transportation
09	Had no place to go
10	Wanted to protect property from looters
11	Wanted to protect property form storm
12	Left unnecessarily in past storms
13	Job required staying
14	Too dangerous to evacuate
15	Other (_____ Specify)
99	Don't Know

4. Did you go to a public shelter, a friend or relative's house, a hotel, or somewhere else?

1	Public Shelter (Red Cross)
2	Church
3	Friend/Relative
4	Hotel/Motel
5	Mobile home park clubhouse
7	Other (_____ Specify)
9	Don't Know

5. Where was that located?

1	In same county as residence	(_____ Name of City)
5	Out of County	(_____ Name of City, County, State)
9	Don't Know	

6. What convinced you to go someplace safer?

(CODE UP TO 3 RESPONSES.)

01	Advice or order by elected officials
02	Advice from Weather Service
03	Advice/order from police officer or fire fighter
04	Advice from media
05	Advice from friend or relative
06	Concern about severity of storm
07	Concern that storm might hit
08	Heard probability (odds) of hit
09	Other (_____) Specify
99	Don't Know

7. When did you leave your home to go someplace safer?

a. Time: ___ ___:___ ___

b. (1) AM
(5) PM

c. Date:

August				
Thu	Fri	Sat	Sun	Mon
20	21	22	23	24

8. How long did it take you to get to where you were going?

___ ___.___ Hours (to nearest 1/2 hour)

Never reached original destination 99.9

9. Did you or anyone in your household require assistance in evacuating, and if so, by whom?

1	Yes, by agency
3	Yes, by friend or relative within household
5	Yes, by friend or relative outside household
7	No
9	Don't Know

10. How many vehicles were available in your household which you could have used in evacuating?

_____ Number of Vehicles

IF "NONE" GO TO Q. 11,
OTHERWISE GO TO Q. 12.

11. Did your household leave with someone else in their vehicle, did you use public transportation, or did you evacuate another way?

1	Other's vehicle
5	Public Transportation
7	Other (_____) Specify
9	Don't Know

GO TO Q. 14.

12. How many vehicles did your household take in evacuating?

_____ Number of Vehicles

13. When you evacuated, did you pull a trailer, boat, motor home, or camper?

1	Yes
5	No
7	Other (_____) Specify

14. Did you hear anyone in an official position -- emergency management, police, etc. -- say that you should evacuate to a safer place?

1	Yes	IF YES, GO TO Q. 15
5	No	IF NO, GO TO Q. 17
9	Don't Know	IF DK, GO TO Q. 17

15. Did they say that you <u>should</u> evacuate or that you <u>must</u> evacuate?

1	Should
5	Must
9	Don't Know

16. Did police or other authorities come into your neighborhood going door-to-door or with loudspeakers, telling people to evacuate?

1	Yes
5	No
9	Don't Know

17. How well do you think the warning and evacuation process was handled in Andrew? (PROBE: What was the problem?)

(CODE UP TO 3 RESPONSES)

1	Good/OK
2	Traffic a problem
3	Transportation a problem
4	Shelters a problem
5	Shouldn't have been told to evacuate
6	Should have been told to evacuate earlier
7	Should have told more people to evacuate
8	Other (_____) Specify
9	Don't Know

18. Would you do anything differently in the same situation again? (PROBE WHY?)

CODE UP TO 3 RESPONSES

1	Would evacuate
2	Wouldn't evacuate
3	Would leave earlier
4	Would wait later to leave
5	Would go further away
6	Wouldn't go as far away
7	Would go to public shelter
8	Wouldn't go to public shelter
9	No
10	Other (_____) Specify
99	Don't Know

19. If the track of the storm had been different, do you think it could have caused flooding in your house?

1	Yes
5	No
9	Don't Know

20. Before the storm, did you know whether you lived in a zone that would need to evacuate in a Category 4 hurricane like Andrew?

1	Yes
5	No
9	Don't Know

21. Before the storm, had you ever seen a hurricane brochure with a map or list of areas that would need to evacuate?

1	Yes
5	No
9	Don't Know

22. Before the storm, had you made any plans about whether you would evacuate and where you would go if a hurricane threatened?

1	Yes
5	No
9	Don't Know

23. How strong do you think the strongest sustained winds were that did the worst damage to houses in Andrew? (if needed: sustainded winds 30 feet above the ground).

1	Less than 100 MPH
2	100 MPH to 124 MPH
3	125 MPH to 149 MPH
4	150 MPH to 174 MPH
5	175 MPH to 199 MPH
6	200 MPH or more
9	Don't Know

24. Many houses in south Dade county were severely damaged or destroyed. Which of the following explanations do you think accounts for most of the damage?

1	The houses were poorly built and didn't meet the building code.
3	The houses met the building code, but the code wasn't adequate to prevent severe damage in a storm as strong as Andrew.
5	Don't Know

25. Do you believe that affordable housing can be built to withstand a storm like Andrew without being severely damaged?

1	Yes
5	No
9	Don't Know

26. If Andrew's strongest winds had hit your home, do you believe there would have been enough damage to make it dangerous to your safety if you had been in the home?

1	Yes
5	No
9	Don't Know

27. Should building codes in your community be stronger, even if it increased the cost of construction?

1	Yes
5	No
7	Depends how much increase in cost
9	Don't Know

28. Should your community spend more on building inspection and code enforcement, even if it increased the cost of building permit fees?

1	Yes
5	No
7	Depends how much increase in cost
9	Don't Know

29. Should mobile homes be banned in your community because of their lack of safety in hurricanes?

1	Yes
5	No
9	Don't Know

30. If another strong hurricane threatened, and public safety officials ordered you to evacuate, what would you do?

1	Evacuate within same county
3	Evacuate outside county
5	Wouldn't evacuate
7	Other (_____) Specify
9	Don't Know

31. If another hurricane threatened, and public officials said that people in your neighborhood should <u>not</u> evacuate because your area won't flood and because the roads would be clogged with traffic if people from your area tried to evacuate, what would you do?

1	Evacuate within same county
3	Evacuate outside county
5	Wouldn't evacuate
7	Other (_____) Specify
9	Don't Know

32. Was anyone in your household seriously injured in the storm?

1	Yes
5	No
9	Don't Know

33. In dollars, about how much damage did your home experience?

0	Less than $100
1	$100 to $999
2	$1,000 to $4,999
3	$5,000 to $9,999
4	$10,000 to $24,999
5	$25,000 to $49,999
6	$50,000 or more
7	Don't Know
9	Refused to Answer

34. Could you live in your house after the storm?

1	Yes
5	No
9	Don't Know

35. Which of the following types of structures do you live in? Do you live in a:

1	Detached single family home?
2	Duplex, triplex, quadruple home?
3	Multi-family building -- 4 stories or less
4	Multi-family building -- more than 4 stories
5	Mobile home
6	Some other type of structure
7	Don't know
9	Refused

36. How old were you on your last birthday?

_____ Number of years

37. How long have you lived in your present home?

_____ Number of years

38. How long have you lived in south Florida?

_____ Number of years

39. How many people live in your household, including yourself?

_____	Number of people

40. How many of these are children, 17 or younger?

_____	Number of children

41. Do you have any pets?

1	Yes
3	No
9	Refused

42. How would you describe your racial group?

1	White
3	Black
5	Hispanic
7	Other (_____)
9	Refused

43. Have you ever been in any other hurricanes?

1	Yes (_____)
	Specify name, year, location
3	No
9	Don't know

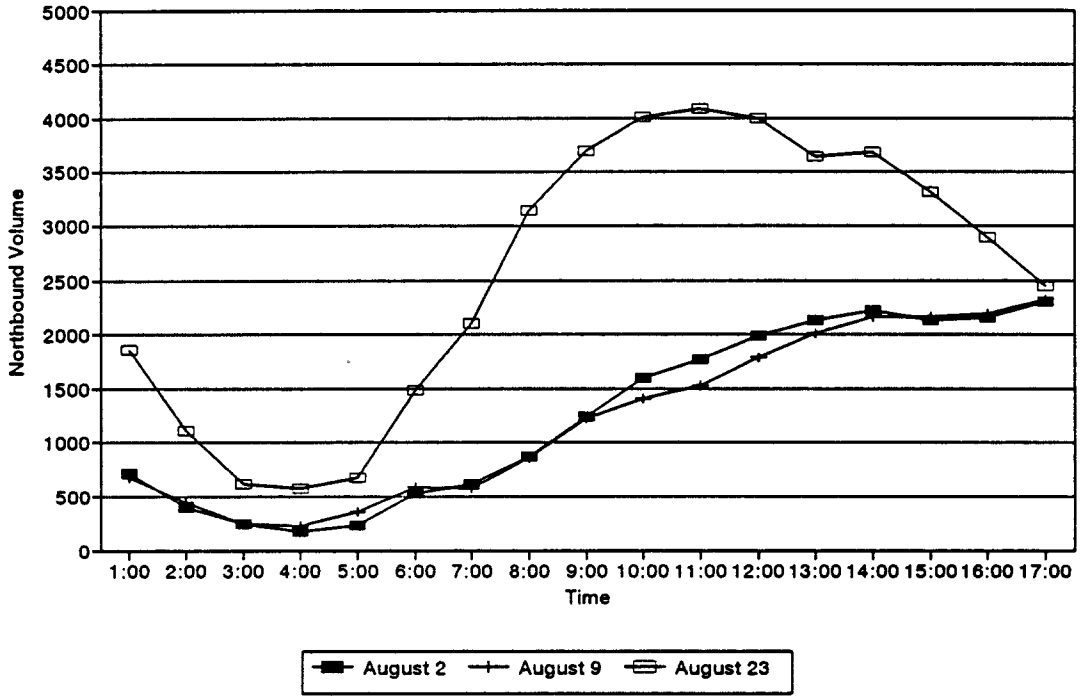
44. Which of the following ranges describes your household income for a year?

1	Less than $12,000
2	$12,000 to $24,999
3	$25,000 to $39,999
4	$40,000 to $79,000
5	Over $80,000
9	Refused

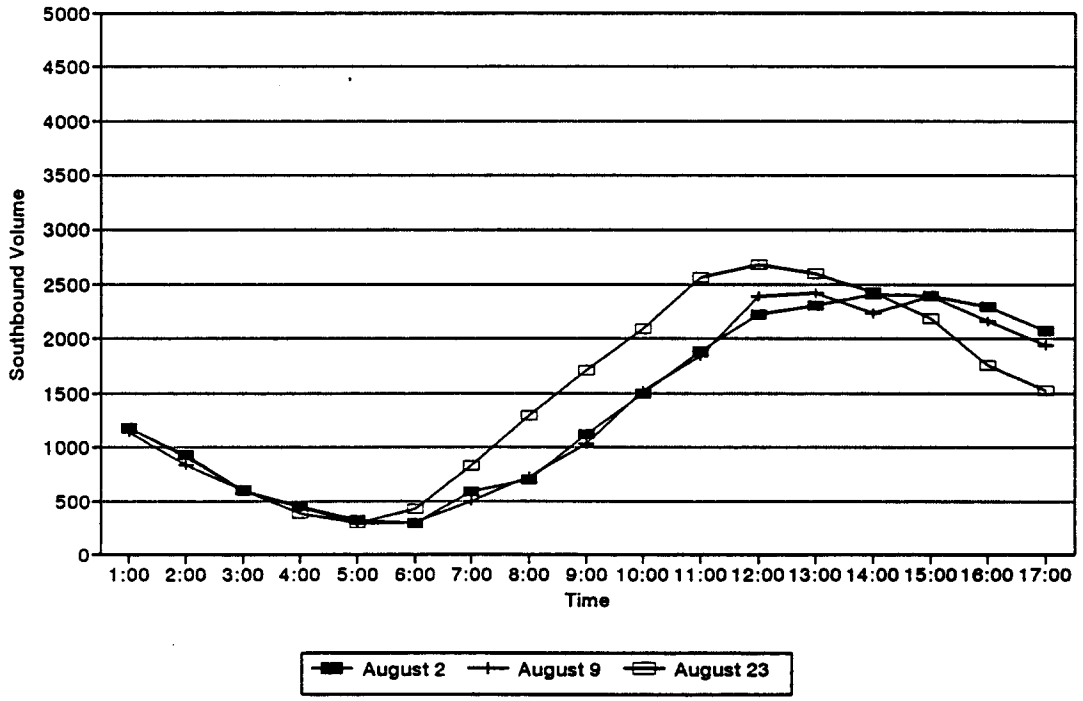
APPENDIX D

Directional Traffic Counts During Hurricane Andrew

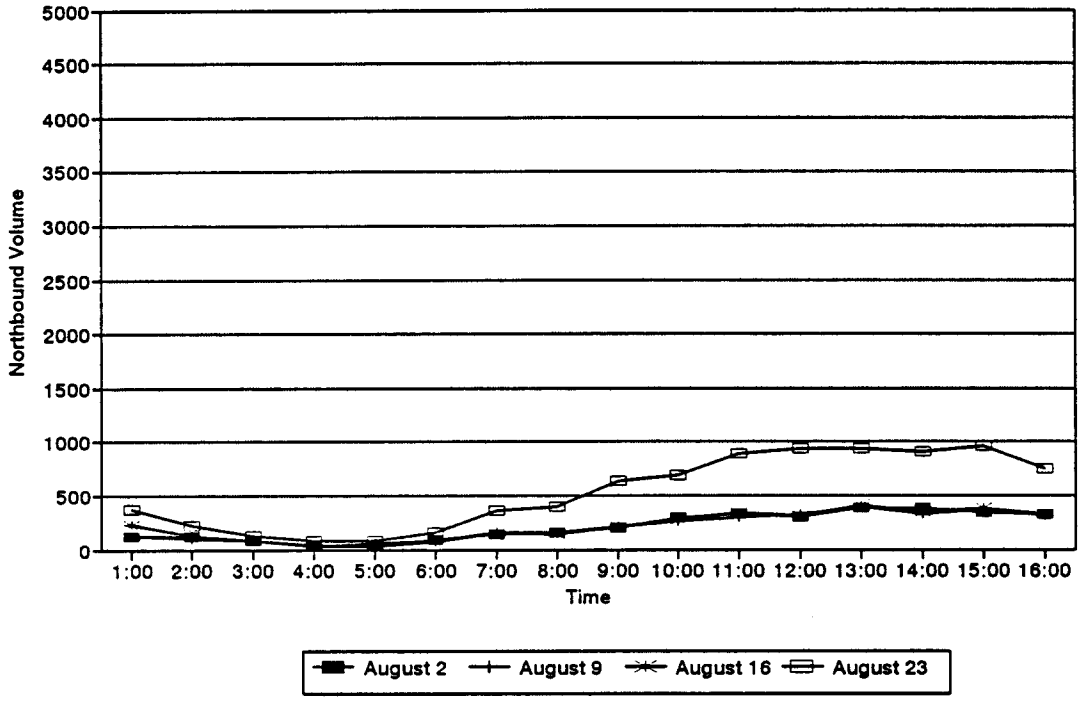
Station 178: Dade County
US-1, South of Granada Blvd, Miami



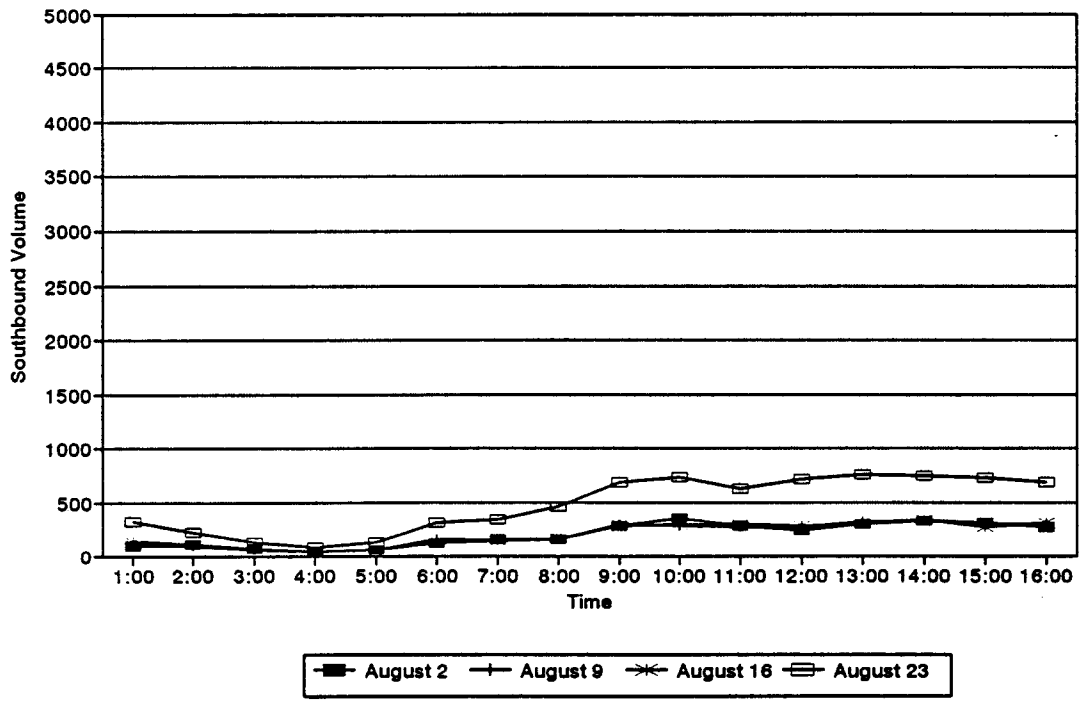
Station 178: Dade County
US-1, South of Granada Blvd, Miami



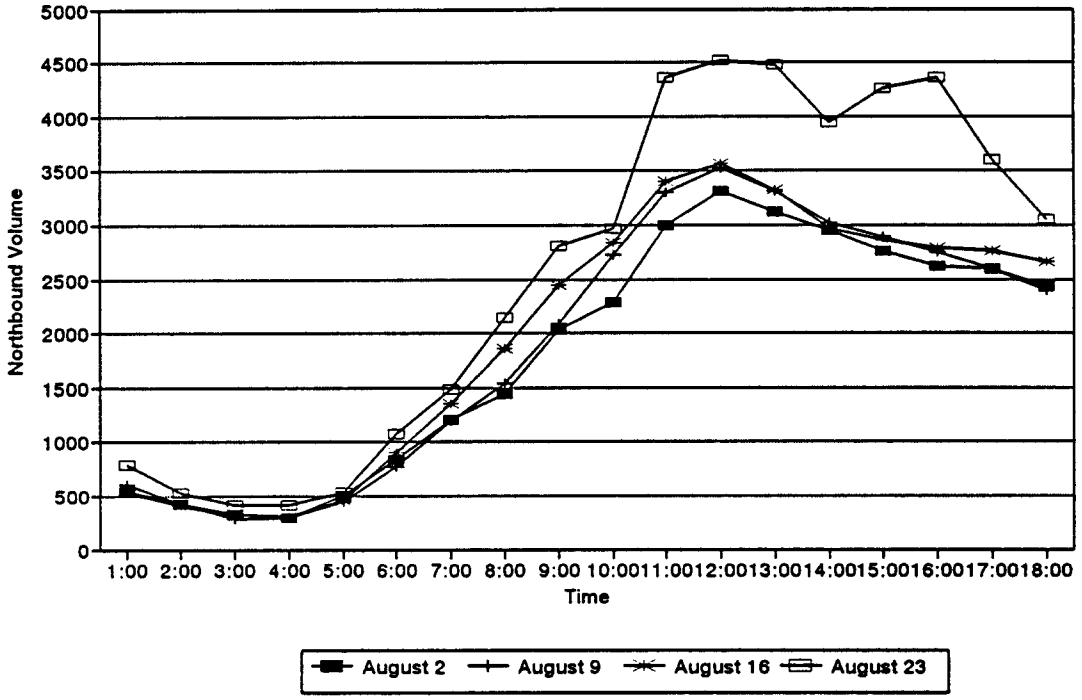
Station 111: Dade County
SR 7/US 441, S of NW 46th St. in Miami



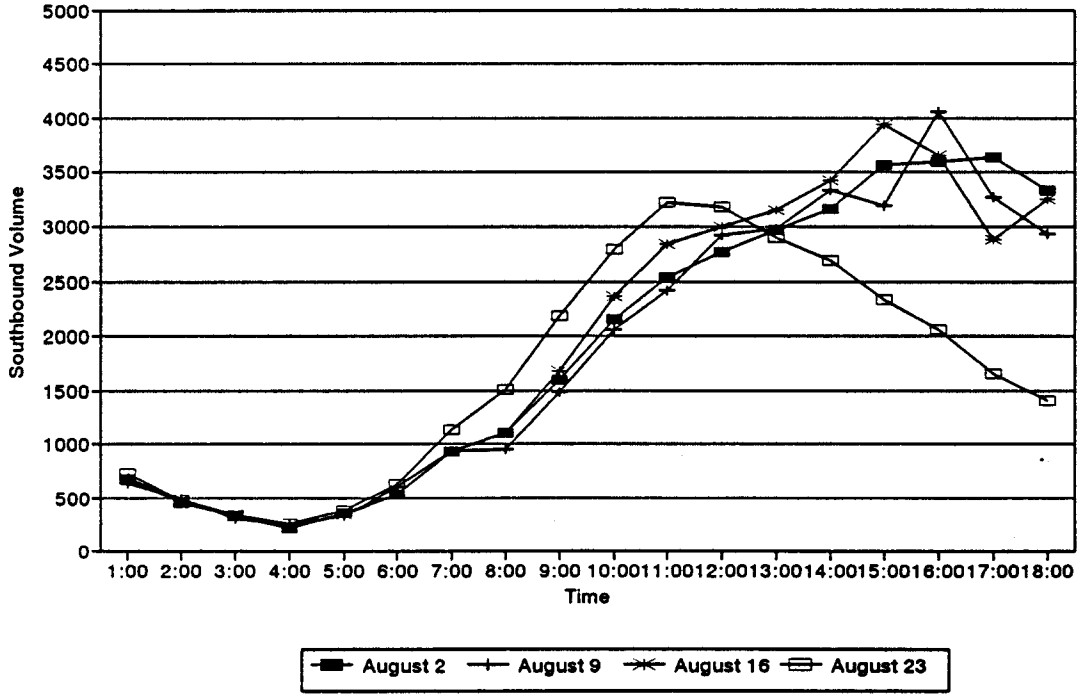
Station 111: Dade County
SR 7/US 441, S of NW 46th St. in Miami



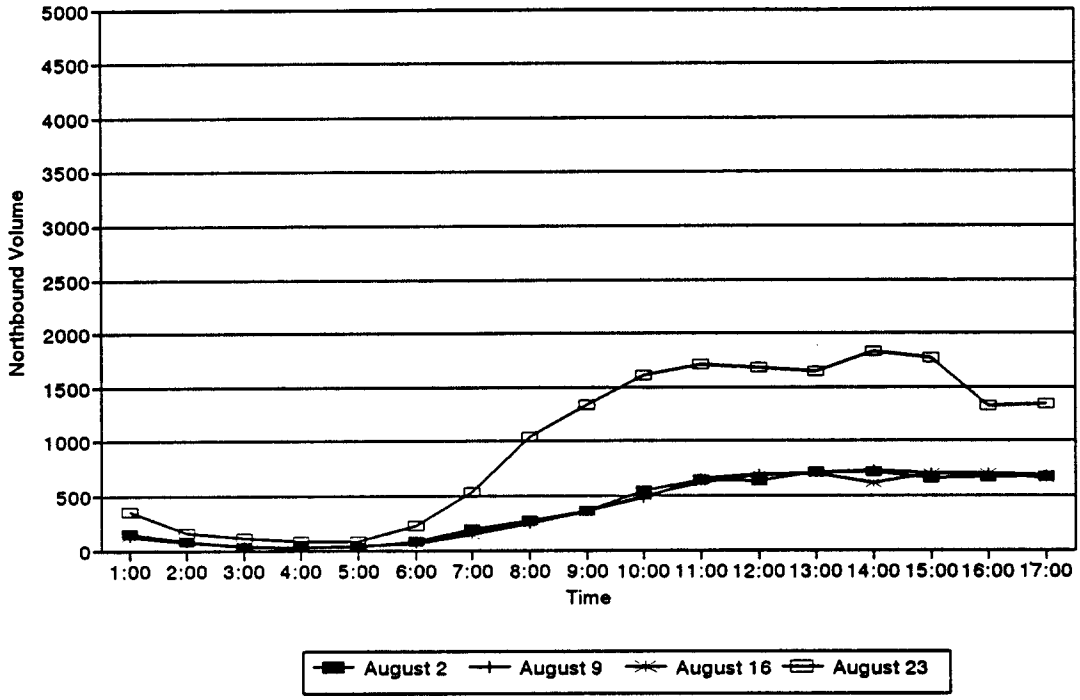
Station 174: Palm Beach County
I-95, SE of Congress Ave, WPB



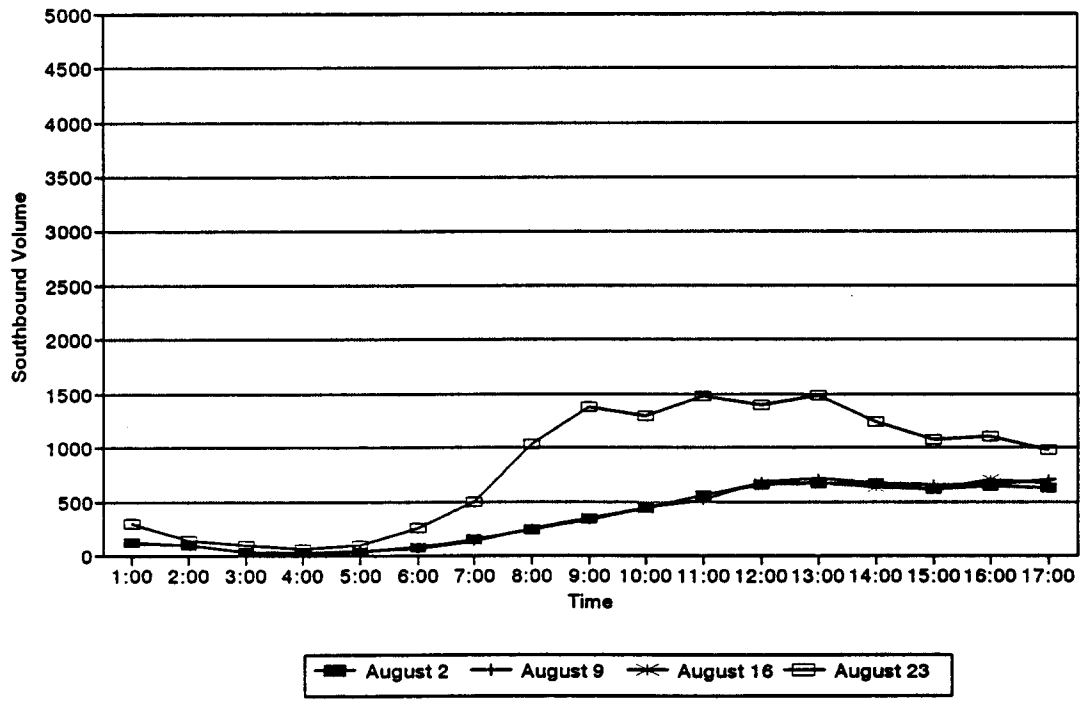
Station 174: Palm Beach County
I-95, SE of Congress Ave, WPB



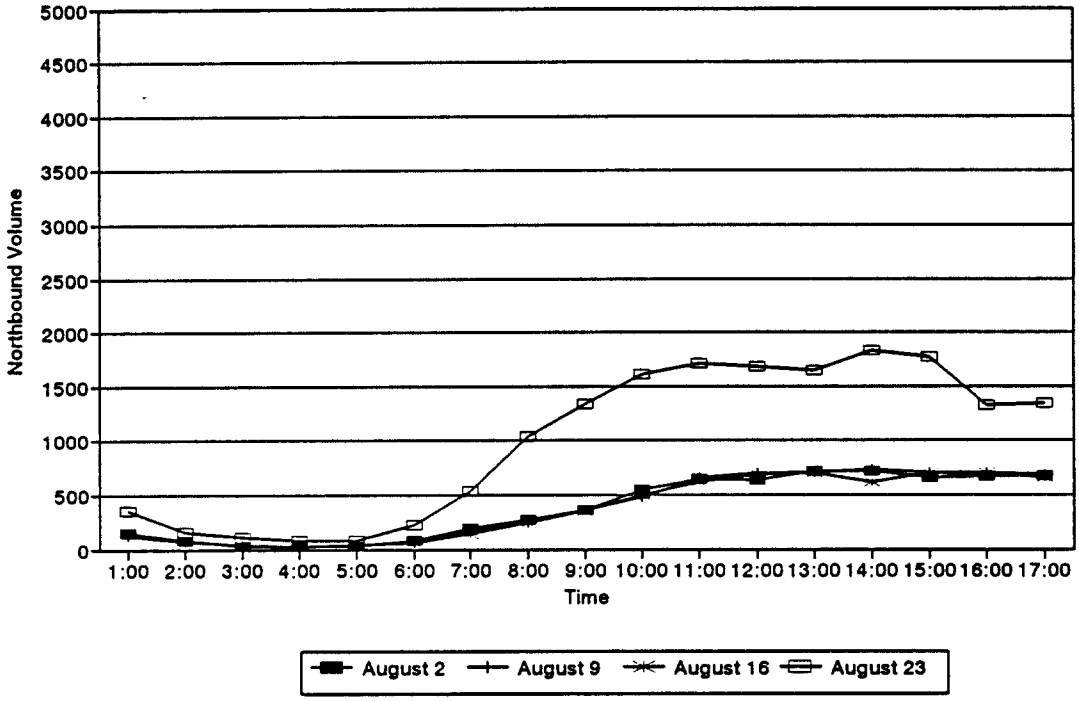
Station 10: Palm Beach County
US 1, 4.5 miles of 806 in Boca Raton



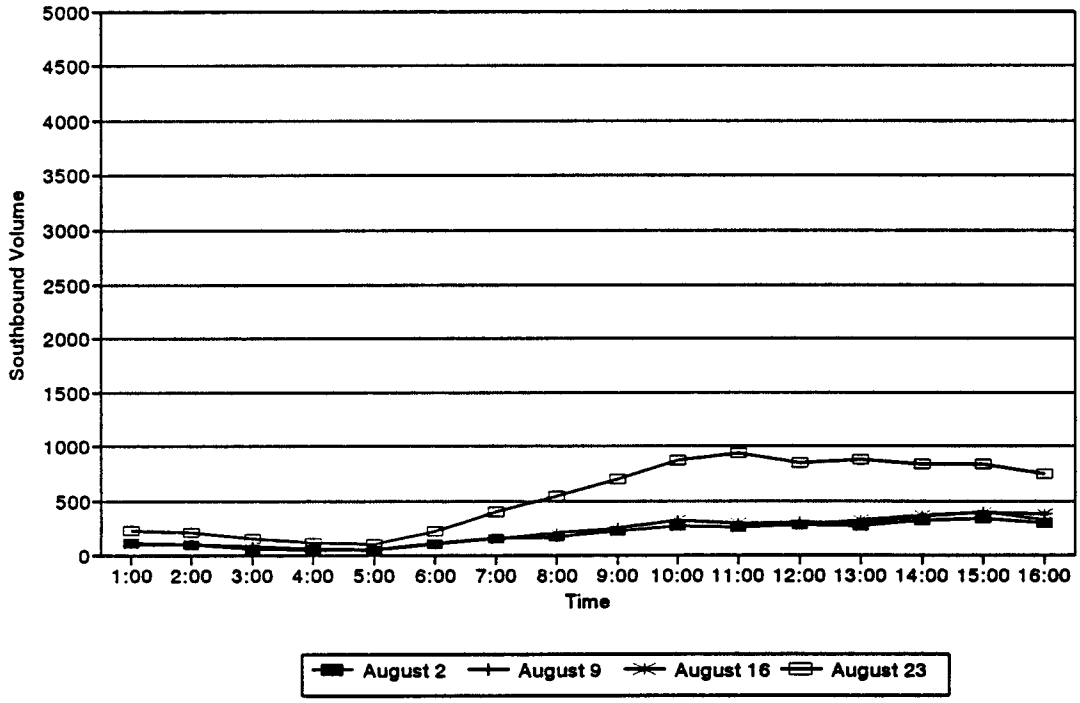
Station 10: Palm Beach County
US 1, 4.5 miles of 806 in Boca Raton



Station 96: Dade County
SR 9, 0.4 miles SW of Biscayne Canal Br



Station 96: Dade County
SR 9, 0.4 miles SW of Biscayne Canal Br



THE NATION'S NEWSPAPER
USA TODAY
PUBLISHED BY GANNETT

"USA TODAY hopes to serve as a forum for better understanding and unity to help make the USA truly one nation."
—Allen H. Neuharth
Founder, Sept. 15, 1982

Peter S. Prichard
Editor
Karen Jurgensen
Editor of the Editorial Page
Thomas Curley
President and Publisher

Andrew's lesson: Disaster planning pays dividends

Florida's smooth evacuation is a testimony to federal, state and local emergency planning.

When Hurricane Andrew struck, South Florida was ready.

That doesn't happen by accident. A remarkably well-choreographed evacuation effort succeeded in convincing an estimated 700,000 people to move out of harm's way.

Such plans are a testimony to intense federal, state and local preparation.

The federal government chipped in with a remarkable piece of computer wizardry called "SLOSH," for "sea, lake and overland surges from hurricanes," that predicts which areas due to be hit by a hurricane will be flooded.

Another computer model predicts how long it will take to evacuate specific areas, so state offices of emergency preparedness know when to start issuing evacuation orders.

Then there are local efforts, like Miami Beach's mock disaster drills for the elderly over the past three weeks.

More grim news is probably on its way, as reports from hard-hit areas come in and the hurricane rages on. But the teams who prepared for this disaster, and those who heeded their warnings, deserve credit for keeping that bad news from being far worse.

By H. Darr Beiser, USA TODAY

SAFE TOGETHER: Aston James gives a drink to 2-month-old daughter Goldie at Miami Beach evacuation center.

▶ Cover story, 1A; index, 3A